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Biology and taxonomy of the Rhopalomyia Gall Midges (Diptera: Cecidomyiidae) of Artemisia tridentata Nuttall (Compositae) in Idaho

by

Robert G. Jones, Station Leader, USDA, APHIS, PPQ, Methods Development, Boll Weevil Eradication Trial, 4120 Reedy Crt. Road, Raleigh, North Carolina 27607

Raymond J. Gagné, Research Entomologist, Systematic Entomology Laboratory, IIBIII, USDA, SEA, AR, c/o U. S. National Museum, Washington, D. C. 20560

William F. Barr, Professor of Entomology Emeritus, University of Idaho, Moscow, Idaho 83843

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ABSTRACT

Twenty-eight species of gall midges have been found associated with big sagebrush, *Artemisia tridentata* Nuttall in Idaho. These species belong to *Rhopalomyia*, subgenus *Diarthronomyia*; 22 are new to science, and 4 are not assigned names. The new species described here are: *anthoides*, *brevibulla*, *calvipomum*, *conica*, *cramboides*, *culmata*, *florella*, *gossypina*, *hirtibulla*, *hirticaulis*, *hirtipomum*, *lignea*, *lignitubus*, *mammilla*, *medusa*, *medusirrasa*, *nucula*, *obovata*, *rugosa*, *tubulus*, *tumidibulla*, and *tumidicaulis*. The 2 previously described species are *R. ampullaria* Felt and *R. artemisiae* (Felt). The latter is given the new replacement name *R. pomum*.

Each species is responsible for a particular kind of gall, and all have similar life histories, differing mainly in their phenological relationship with the plant. The galls are specifically localized on all developing aerial parts of the host. The eggs of the several species observed are deposited separately or in masses on the surface of the plant near or on the part to be infected. Larval and pupal development occur within the galls, with the larva overwintering. Adults emerge shortly after the pupae break through the gall surface. Each day males emerge shortly before the females to begin to fly concurrently with female emergence at sunrise. Males, singly or in swarms, seek out the females and mate repeatedly. Females mate once and begin oviposition a few hours later. Most, if not all, activity of these short-lived adults is over by midday. Twenty-two species are univoltine, 2 bivoltine.

The impact of galls on the plant ranges from mortality to no apparent effect. Some gall midge species are limited in their potential destructiveness by platygasterid and chalcidoid parasitoids. *Oxyna palpalis* (Coquillett), a tephritid fly, and *Apion sordidum* Smith, a curculionid beetle, are inquilines in several of the larger galls.

INTRODUCTION

Sagebrush, *Artemisia* spp., is a dominant plant group in extensive areas of western North America. It holds an important and sometimes conflicting role in range and wildlife management programs: there are needs both for its protection as browse and cover shrubs and for its control in order to increase grassland grazing areas. In Idaho, sagebrush vegetation or several types derived from it occupy an estimated 17 million acres (Tisdale et al. 1969). One of the species, *Artemisia tridentata* Nuttall, host to the gall midges treated in this study, occurs on most of this acreage.

Insects galls are common on *Artemisia* species and sometimes occur in such large numbers that they are probably an important factor in the ecology of sagebrush. Yet, until this study, these galls and their gallmakers (Figs. 1 and 2) were poorly known. Eleven species of gall midges (Cecidomyiidae) reared from galls on *Artemisia* from western North America were named and cursorily described, but subsequent recognition of most of these midges was impossible because the stage or sex bearing the characters needed for discrimination were unknown. Although the galls made by some of these midges were described in recognizable detail, in most cases species identification based on the gall was difficult because the precise host species were unreported and more than one kind of gall was purportedly made by the same species of gall midge.

This study was undertaken to ascertain the identity of the gall makers, to study their life history and the development of the galls, and to investigate the effect of the galls on the host plants. The scope of the project was limited to big sagebrush, Artemisia tridentata and its subspecies, in the general area of southern Idaho. Using this widely distributed host in such a large area we hoped that our results, even though incomplete for many species, would allow us to predict with confidence the biology and impact of gall midges on other Artemisia species in Idaho and elsewhere.

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METHODS

Field Studies

Gall collections, rearings, and detailed study of gall midges were made throughout the sagebrush region in Idaho. More than 140 locations were involved. The collections were begun in 1955, the detailed study commenced in April 1968 and continued through July 1970, with short collecting periods subsequent. A few collections were also made on A. tridentata in Montana, Nevada, Utah and Washington at sites adjacent to Idaho. Up to 39 visits to a specific site were made during the detailed study period, depending on the presence and abundance of galls. These specific study sites are listed in Table 1.

Some galls were left undisturbed on plants at different sites for periodic observation of gall development. Other galls were collected for rearing and dissection. The gall dissections were made at two to four week intervals, except from December through February, for each of the more common midge species to follow larval and pupal development. Weather conditions permitted only one or two collections during the three winter months.

Samples of galls of each midge species were collected from each site for a reference collection. At first, these were preserved in either 70% ethanol or FAA (Formalin, 1 part; glacial acetic acid, 1 part; 50% ethanol, 18 parts). Later we preserved the galls on insect pins because dried galls do not shrink or discolor. Foliage was collected and examined in the laboratory for small galls or early developmental stages of galls. To rear adults in the laboratory, supplemental field collections of galls were made when pupae were fully developed. The size of all these collections depended on the abundance of galls.

Adult behavior studies were conducted on 3 midge species. Rhopalomyia pomum was studied at Sites 1 through 4, R. ampullaria at Site 13, and R. gossypina at Site 24. Ten plants with large numbers of galls were selected and tagged for identification at each site. During the hour before dawn five 4" x 4" dark green boards with mineral oil on both surfaces were hung on separate branches of each plant. Counts were taken of trapped adults at hourly intervals from sunrise to midday, when adults were no longer active. Temperature, humidity, and wind velocity were recorded hourly. Emergence, mating, and oviposition were observed between hourly recordings.

At each of the R. pomum sites five of the 10 tagged plants were examined for distribution of the galls. The plants were divided into north-south and east-west quadrants and a center section. All branches were removed from each of the five sections and gall counts made. The effect of gall formation on the buds of these plants also was noted.

Caging studies were conducted on R. pomum and R. gossypina to determine whether these midge species consistently cause the same gall type on different plants as the one from which they emerge. The studies were done in a test plot at the USDA Entomology Research Station at Twin Falls. In the fall of 1968 and spring of 1969, numerous young, gall free plants of A. t. tridentata and A. t. vaseyana were transplanted into the test plot. The test plot was well isolated from other sagebrush plants. As the pupae of each midge species in field collected galls neared maturity, the galls were taken from rearing containers and placed with several individually screen-caged plants in the test plot. After about a week the galls and the cages were removed. Each plant was examined throughout the season and the following spring to determine whether gall development occurred and whether it was typical of that midge species.

Laboratory Studies

Adult gall midges were reared for identification and for verification of their association with the gall and host plant. Best results in obtaining adults came from galls containing mature pupae. Galls were separated by form, plant part affected, collection site, and collection date and reared at room temperature individually or in mass in vials and plastic bags. Moisture was a problem in both types of containers and mold was common. Daily records were maintained of all emerged specimens, including parasitoids and asociated insects. Specimens were preserved in 70% ethanol or pinned.

An intensive rearing study was conducted with three midge species (R. pomum, R. ampullaria, R. gossypina). Fifty galls of R. pomum from each of Sites 1, 3 and 4 and 43 galls from Site 2 were collected prior to adult emergence. Each gall was measured and placed in a 40 dram plastic vial or small jar. Daily emergence records were kept. A few females (adults and pupae that wiggled from the galls) were preserved in Bouin's solution for subsequent egg counts. All other specimens were preserved in 70% ethanol. The same general procedure was followed for the other two midge species except for R. ampullaria 90 leaves bearing one to 20 galls were placed in individual rearing chambers. Fifty galls of R. gossypina were preserved in 70% ethanol after 16 days in rearing, and the larval capsules were subsequently counted and examined.

Egg masses of the midge species were field collected whenever possible and preserved in 70% ethanol. These and egg masses dissected from adults and pupae were counted and measured under a dissecting microscope.

Over 1,000 specimens were studied taxonomically, and most were collected expressly for this study. For detailed examination it was usually necessary to mount specimens on slides for viewing under a phase contrast microscope. Permanent mounts were made with Canada balsam. Anatomical drawings were done either from these slides or from cleared specimens placed in a drop of glycerin on a depression slide.

Most of the study material including the holotypes of the new species is deposited in the U.S. National Museum of Natural History (USNM). A synoptic collection is at the University of Idaho, and paratypes of most species as available have been deposited in the California Academy of Sciences, San Francisco. Most of the extant types of the previously described Nearctic species of Rhopalomyia are in the U.S. National Museum of Natural History, either in the regular collection or in the Felt Collection, which is on loan

Table 1. Locations, elevations, and host plants of study sites mentioned in the text.

Site #	Location	Elevation	Sagebrush Taxa
	Twin Falls Co.		
1	5 miles east of Twin Falls	3746 feet	A. t. tridentata A. t. wyomingensis
2	11 miles south of Hansen	4300 feet	A. t. tridentata
3	23 miles southwest of Twin Falls	4950 feet	A. t. tridentata
4	17 miles south of Hansen	4725 feet	A. t. vaseyana
5	21 miles south of Hansen	5240 feet	A. t. vaseyana
6	22 miles south of Hansen	5700 feet	A. t. vaseyana
7	Magic Mountain Ski Areas	6400 feet	A. t. vaseyana
	Blaine Co.		
8	Galena Summit	8600 feet	A. t. vaseyana
	Butte Co.		
9	0.5 miles west of Arco	5300 feet	A. t. tridentata
	Camas Co.		
10	11 miles north of Fairfield	6500 feet	A. t. v. f. spiciformis
11	12 miles south of Fairfield	5450 feet	A. t. vaseyana
	Canyon Co.		
12	15 miles south of Nampa	2500 feet	A. t. wyomingensis
	Cassia Co.		
13	4 miles west of Almo	6200 feet	A. t. tridentata A. t. vaseyana A. t. wyomingensis
	Custer Co.		
14	8 miles northwest of Mackay	6200 feet	A. t. vaseyana
	Elmore Co.		
15	3 miles north of Mt. Home	3325 feet	A. t. wyomingensis
16	7 miles south of Mt. Home	3000 feet	A. t. wyomingensis
	Franklin Co.		
17	28 miles northeast Preston	6850 feet	A. t. v. f. spiciformis
18	3 miles west of Dayton	4800 feet	A. t. vaseyana
	Gooding Co.		
19	11 miles south of Bliss		A. t. tridentata
20	3 miles southeast of Bliss	3140 feet	A. t. wyomingensis
21	9 miles west of Bliss	3000 feet	A. t. tridentata A. t. wyomingensis
22	3 miles south of Hagerman	2964 feet	A. t. wyomingensis
	Lincoln Co.		
23	11.5 miles west of Kinama	4275 feet	A. t. tridentata
	Minidoka Co.		
24	2 miles east of Acequia	4200 feet	A. t. tridentata
	Oneida Co.		
25	9.5 miles west of Malad	5200 feet	A. t. vaseyana
	Teton Co.		
26	4.5 miles west of Tetonia	6025 feet	A. tripartita
	Washington Co.		
27	8 miles north of Weiser	2580 feet	A. t. v. f. xericensis
	Beaverhead Co., Montana		
28	17 miles east of Bannock Pass Summit		A. t. tridentata
	Adams Co., Washington		
29	1.2 miles north of Washtucna		A. t. tridentata

to the Systematic Entomology Laboratory from the New York State Museum, Albany. The type of *Rhopalomyia tridentatae* Rübsaamen was obtained from the Staatliches Museum für Naturkunde, Stuttgart, West Germany.

Systematic Presentation

The arrangement of the midge species is in order by location on the plant as indicated in Table 2. Under each species we present our information concerning its taxonomy and anatomy, its biology, the gall, associated insects, and its host plants and geographical distribution. Letters are assigned to distinguish among unnamed species of the parasitoid genus *Platygaster.* The subspecies *Artemisia tridentata wyomingensis* and *A. t. vaseyana* "form *xericensis*" were not recognized during the first season of this study; thus host identification for sites not visited after 1968 is only at species level. In general, R. G. Jones and W. F. Barr are responsible for the field data in this study, R. J. Gagné for the gall midge systematics. Gagné is the author of the new species.

The specific names chosen for the new taxa describe some aspect of the galls. Following is an alphabetical list of each valid specific name and its meaning (all except *ampullaria* and *pomum* are new): *ampullaria* (adjective), ampulelike; *anthoides* (adj.), flowerlike; *brevibulla* (noun), short bump; *calvipomum* (n.), smooth apple; *conica* (adj.), cone-shaped; *cramboides* (adj.), cabbagelike; *culmata* (adj.), stalked; *florella* (n.), little flower; *gossypina* (adj.), cottony; *hirtibulla* (n.), fuzzy bump; *hirticaulis* (n.), fuzzy stem; *hirtipomum* (n.), fuzzy apple; *lignea* (adj.), woody; *lignitubus* (n.), woody tube; *mammilla* (n.), small teat; *medusa* (n.), Medusa; *medusirrasa* (n.), fuzzy Medusa; *nucula* (n.), little nut; *obovata* (adj.), obovate; *pomum* (n.), apple; *rugosa* (adj.), rugosa; *tubulus* (n.), little tube; *tumidibulla* (n.), swollen bump; *tumidicaulis* (n.), swollen stem.

HOST PLANTS

Several taxonomic units are included under the species *A. tridentata*. Beetle (1960) recognized two subspecies and two forms, each occurring in Idaho. These are basin big sagebrush, *A. t. tridentata*; mountain big sagebrush, *A. t. vaseyana*; Parish sagebrush, *A. t. tridentata* form *parishii* and subalpine sagebrush, *A. t. vaseyana* form *spiciformis*. Further study (Beetle and Young 1965) resulted in the recognition of the third subspecies of this complex: Wyoming big sagebrush, *A. t. wyomingensis*. Winward and Tisdale (1977) studied the taxonomy and ecology of this complex in Idaho. They found important taxonomic characters in the number of flowers per head and heads per stalk, vegetative and flower stem length, and leaf length-width ratios. They established the distribution of all subspecies in the state, confirmed the validity of *A. t. vaseyana* form *spiciformis* and recognized a previously undescribed taxon which they tentatively referred to as *A. t. vaseyana* "form *xericensis*." Winward rejected the *A. t. tridentata* form *parishii* because the distinguishing character of a drooping inflorescence is present in both *A. t. tridentata* and *A. t. wyomingensis* and cannot be related ecologically or geographically.

Sagebrush vegetation extends over much of southern Idaho (Tisdale et al. 1969). Winward (1970), in studying the distribution of *A. tridentata* in Idaho, found *A. t. tridentata* to have an elevation range of 2500 to 7000 feet and a preference for the deep, well-drained soils of valley bottoms and lower foothill regions. *Artemisia t. vaseyana* is found at elevations from 4500 to 8000 feet on relatively deep soils throughout the upper foothill and mountain areas. The form *spiciformis* nearly always occurs at elevations about 7000 feet and is restricted to localized mesic sites. The "form xericensis" (= A. tridentata "X" as characterized by Winward and Tisdale, 1977) is known in the west-central portion of the state where it occurs in relatively dry sites in an elevation range of 2500 to 4500 feet. Artemisia t. wyomingensis occurs at relatively shallow soils of the hotter and drier portions of the state at elevations ranging from 2500 to 6500 feet.

Dietert (1938) found the most striking characteristics of A. tridentata to be its evergreen foliage and absence of winter buds. Due to these features the stem tip has much the same appearance throughout the year. Two types of branches, flowering and vegetative, are produced each year. In early growth there is no apparent difference between the two, either externally or internally. However, on about the first of June when the new branches have reach a length of 5 - 15 cm or more, external differences gradually become apparent. From this time on the flowering branches elongate more rapidly. These die with the ripening of the seed in the fall, but usually persist on the plant until the following summer or even for several years.

The flowering branches or sprays are panicles with small, sessile heads. The bracts or leaves that subtend the branches of the flowering spray vary from typical tridentate leaves near the base of the spray to much smaller entire linear ones toward the apex. These bracts, as a rule, are shed before the flowers reach maturity.

Two leaf series occur on the vegatative branches. Winward and Tisdale (1977) refer to these as ephemeral and persistent leaves. The irregularly lobed ephemeral leaves are produced early in the year and are shed as the season advances. Persistent leaves are typically three-lobed and remain on the plant through the winter. All leaves, bracts, and current year's growth of branches are densely clothed with trichomes, giving them a silvery gray appearance.

Winward and Tisdale (1977) also reported phenological differences among the three subspecies and two forms of A. tridentata. Artemisia t. tridentata and A. t. wyomingensis begin growth approximately 2 weeks earlier and have ripened seeds at least two weeks later than A. t. vaseyana.

THE SAGEBRUSH GALL MIDGES

Biology

Except for some spatial and phenologic variations, the life histories of the gall midges appear to be quite similar. The only other species of the subgenus Diarthronomyia whose biology has been studied in any detail is R. chrysanthemi Ahlberg, as summarized in Barnes (1948). Its biology is similar to that of the species treated here except that instead of the one or two generations per year for these sagebrush associated species, R. chrysanthemi may have up to five.

Egg

Eggs of the several species observed are similar in appearance in gross aspect and differ only in size. The eggs are deposited singly or in masses on the surface of the plant near or on the special part where gall development occurs. The duration of this stage has not been determined, but in R. pomum at least, it is less than 16 days. Barnes (1948) reported that this stage lasts from three to 22 days for R. chrysanthemi, depending on temperature.

Larva

All species overwinter as larvae within the gall, but the age of the overwintering larva varies among species. The overwintering larval age appears related to the phenology of the host plant. Species such as R. pomum and R. hirtipomum overwinter as young larvae in galls which are first evident in the fall. At the other extreme, R. obovata overwinters as mature larvae in galls which have completed development and are beginning to deteriorate.

Eclosion and other activities of immature larvae were not observed, but Barnes (1948) found that larvae of R. chrysanthemi move about on the plant surface and bore into the tissue within 24 hours after eclosion. Spence (1969) found that newly hatched larvae of R. hirtipes (Osten Sacken) also are quite mobile. This may explain why galls of certain sagebrush associated species, e.g. R. brevibulla, are produced on plant organs other than those on which their eggs are deposited. The penetration of the plant tissue by larvae is evident by the brown spots or scars on the surface of the galls of R. pomum and R. calvipomum.

The time lapse between oviposition and gall development varies with the midge species. For example, galls of R. pomum were not evident until four months after oviposition while those of R. obovata could be found about two months after oviposition. Barnes (1948) reported a time lapse of 16 to 102 days between larval penetration into the plant tissue and the appearance of a visible gall for R. chrysanthemi, but that variation was seasonal and could be altered under greenhouse conditions. A shortened time lapse was obtained in this study with greenhouse incubation of the galls of R. gossypina. These galls were visible about January 20 under greenhouse conditions while those developing under field conditions were not visible until early June.

Pupa

Pupation occurs within the larval chamber of the gall and appears to be brief; for R. pomum this stage lasts about 15 days. The duration probably varies according to species to within a week or so of this depending on weather conditions. Barnes (1948) found it to vary from six to seven days to several weeks for R. chrysanthemi depending on the season. With maturity the abdomen of the female pupa becomes red.

The pupa escapes the gall either by cutting its way out or by breaking the gall. The antennal and facial horns of the pupa are used in this activity. There may be a correlation between the prominence of the antennal horns and the most solidly walled galls.

When the pupa reaches the outer gall surface, the adults emerges. The pupal exuviae are left attached to the gall. The presence of exuviae is useful in ascertaining the occurence and extent of emergence.

Adult

The seasonal occurrence of adults is related directly to the phenology of the host plant. Midges emerge at or about the time of the development of the plant organ or part on which the galls occur. Midge emergence and both midge and gall development varied between sites: later development in the spring coincided with elevation and geographical areas in Idaho that consistently had later growing seasons. Observations were in general agreement with Winward and Tisdale (1977) that A. t. vaseyana begins growth two weeks later and ripens seed at least two weeks earlier than A. t. wyomingensis and A. t. tridentata. This generally explains the later emergence of R. pomum at Site 4, where only A. t. vaseyana was present. At Site 13, however, three subspecies of *A. tridentata* occurred intermixed within the same area. The phenology of all three was similar, and *R. ampullaria* which occurred on each, emerged concurrently from each subspecies.

Midges emerge through a dorsal split in the thoracic exoskeleton of the pupa. Emergence is influenced by temperature and relative humidity, with different thresholds of these factors apparent for males and females of a species. Light also may be a factor. Males consistently emerge earlier in the morning than females when the temperature is lower, relative humidity higher, and apparently before daylight in most instances. Females emerge at sunrise or shortly thereafter. Emergence and other adult activities take place during a daily period of high relative humidity. Humidity may be of special importance in a desert community, where desiccation would be fatal to the adults.

Male flight occurs when light and temperature are favorable. The minimum temperature at which flight was observed was 48°F. The primary function of male flight is to seek out females and mate. Observations and trapping indicate that males seek females both individually and in male swarms, at least for *R. pomum*, *R. ampullaria* and *R. gossypina*.

The sex ratio for *R. pomum* favors the female (see under that species). Assuming that males are as efficient in seeking out females as they apear to be, the high female to male ratio provides the required high reproductive potential to offset possible catastrophies. Observations showed females of *R. pomum* and *R. gossypina* mate only once, while males of these species mate several times.

Host Plant and Geographical Distribution

Galls were found on all subspecies and forms of *A. tridentata* throughout the study area in Idaho. However, it is doubtful that all midge species associated with *Artemisia tridentata* in Idaho have been found. The distribution of these midge species outside of Idaho is not known, although limited observations in Montana and Washington showed only one gall different from those found in the state. Fronk et al. (1964) in their work in Wyoming on dipterous galls of the *A. tridentata* complex, recorded a midge species, *Asphondylia* sp. on *A. tridentata*. This genus was not encountered in the present study.

Gall

The structural variety of midge galls on *Artemisia* is remarkable. Galls are found on all non-woody aerial growth: the two leaf series, flower and vegetative buds, leaf and stem nodes, and green stems (Table 2). The majority of galls occur on the plant parts that remain through the winter. The exceptions to this are the galls of the ephemeral leaf series which remain on the plant for a relatively short period. Two gall midges form galls on this leaf series. One, *R. ampullaria*, has two generations per year. The second generation forms the same type of gall as on the ephemeral leaves but on the flower buds instead, in which the larvae overwinter. *Rhopalomyia culmata*, which causes the second kind of ephemeral leaf gall, probably has another generation, but we did not find it.

The seasonal occurrence of these two galls appears directly correlated to that of normal plant growth. Development of the galls generally begins with the start of normal growth of that part on which they occur, and ceases when normal growth stops. This is most apparent in both leaf and flower bud galls of *R. ampullaria*. The development of the galls on the persistent leaf series opens some questions, however, Dietert (1938) stated that the persistent leaves overwinter as mature leaves on the plant and are dropped soon after growth is resumed in the spring. If this is true, then these galls develop mostly on a mature organ. Further study may show that the persistent leaf series is similar to the embryonic leaves which Dietert believes have been arrested in various stages of development in the fall and resume their growth in the spring.

Those midge species which have the greatest impact on their host plant appear to be those which cause bud galls. These prevent further plant growth by killing the bud. However, most infested plants are not severely damaged because of generally low numbers of this type of gall and because the impact of these gall causing midges is lessened by the large number of parasitoids associated with them.

The galls are prosoplasmatic, which means that their form is constant in size and structure and is the result of a restructuring of the plant cells. As to their cause, we cannot improve on Kinsey's (1936) noncommital definition that galls are the "expression of the physiologic nature of the stimulus provided by the insect."

Systematics

All gall midges encountered in this study belong to the subgenus Diarthronomyia of the genus Rhopalomyia (Gagné 1975), one of the larger genera of the supertribe Oligotrophidi. Rhopalomyia is characterized by the following combination of characters: the presence of one or two palpal segments, blunt-tipped claspettes of the male genitalia, ovoid female cercus, longer legs and wings in males than in females, and the lack of a spatula and the general reduction in number and size of the papillae in the larvae. In addition, all included species cause complex galls that are found chiefly on Compositae.

Species of the subgenus Diarthronomyia are distinct from other Rhopalomyia on Compositae in the lack of lateral setae on the adult abdominal terga. Also, unlike other Rhopalomyia, many species of Diarthronomyia have teeth on the tarsal claws. The subgenus is at least Holarctic and its species occur exclusively on species of Artemisia and Chrysanthemum.

The reduction in the number of useful diagnostic characters in Rhopalomyia as compared with some other groups of cecidomyiids is striking. The palpus and antenna have a reduced number of parts and can vary in shape within a species. Setation is generally reduced and even the trichoid sensilla, the two sensory setae present at the base of the abdominal sterna of almost all gall midges, show reduction in these Artemisia associated midges from two to one or none. The larva has lost the sternal spatula and the few terminal papillae remaining are barely perceptible. Nevertheless it has been possible to recognize apparent relationships among certain species, and these are discussed in the species diagnoses.

In the past, Diarthronomyia midges were formally segregated according to the expression of a few characters such as the number of palpal segments and the presence or absence of teeth on the tarsal claws (Gagné 1975). The present study shows that although such characters are helpful for separating species, they are by themselves of no use in determining evolutionary relationships. For example, R. hirticaulis has simple tarsal claws and R. tumidicaulis toothed claws, but apparent similarities in the shape of the male genitalia and pupal heads and the location and structure of the galls indicate that the two species are closely related.

In this study, we recognize 26 species of Rhopalomyia on A. tridentata, each of which was reared from a distinct type of gall. Males and pupae from most of these can be distinguished anatomically from all others, but there are two pairs of species whose members appear identical. These are R.pomum, R.

Table 2. Summary of the gall forms on different plant organs by midge species with seasonal occurrence, host and geographical prominence in Idaho, 1968 through 1970.

Midge Species	Generalized Seasonal Occurrence of Gall	Occurrence at or on number of		
		A. tridentata sites in Idaho	*A. tridentata* Taxa	Other *Artemisia* spp.
Galls of the Persistence Leaf Series				
R. pomum	October to June	97	3	4
R. calvipomum	October to June	20	4	1
R. hirtipomum	October to June	12	4	0
R. tubulus	October to June	5	2	0
R. rugula	October to May	1	1	0
R. hirtibulla	October to April	8	3	0
R. brevibulla	October to April	1	1	0
R. tumidibulla	October to May	2	1	0
Galls of the Ephemeral Leaf Series				
R. ampullaria	May to August	10	3	1
R. culmata	May to June	3	3	0
Galls of the Branch Tips (Buds)				
R. gossypina	May to October	4	1	1
R. lignea	August to May	4	2	0
R. sp. nr. *lignea*	August to May	5	1	2
R. lignitubus	March to June	8	4	0
R. cramboides	June to May	8	2	0
R. anthoides	June to April	23	4	0
R. florella	June to April	3	2	0
R. conica	March to June	23	4	3
R. mammilla	March to October	8	3	0
R. obovata	June to April	53	4	2
Galls of the Leaf and Stem Nodes				
R. nucula	June to April	35	4	1
R. medusa	September to May	75	5	4
R. medusirrasa	October to May	14	1	0
Galls of the Stem				
R. hirticaulis	May to August	2	1	0
R. tumidicaulis	May to September	1	1	0
R. ampullaria	May to April	1	3	0
Galls of the Flower Buds				
R. ampullaria	September to September	1	3	0

hirtipomum and *R. medusa*, *R. medusirrasa*. The galls formed by members of each pair are similar in location on the plant and gross structure except that galls of one member of the pair are fuzzy; of the other, smooth. Cage experiments with *R. pomum* support the conclusion that succeeding generations of the midges make galls that are true to parental form. Consequently, the members of each pair can be recognized by characteristics of their galls.

Rhopalomyia, being a dynamic group of insects, should reflect the gradations that are part of the process of speciation. Not only might there be long established species that have become anatomically distinct from their sister species, there might also be some species pairs that have more recently diverged and whose existence is less demonstrable anatomically. As indicated above, we have some cases of similar specimens being reared from different types of galls that retain their identity through successive generations. We assume that the galls are the expression of the chemical reactions between the plant and the salivary secretions of the larvae. Therefore, if the galls are distinct, the genetic makeup of the gall midges is distinct also. Most of the gall midges from the several gall types are different, at least in male and pupal characters. Females are less distinct and larvae even less so. Therefore, our working species definition for these in the subgenus *Diarthronomyia* is as follows: a species is a population that is usually distinguishable in the totality of its anatomical characters and that is responsible for one particular type of gall on its host plant species.

A problem barely touched upon here concerns the fact that similar galls from different *Artemisia* species do not yield the same species of *Rhopalomyia*. For example, galls similar to those of *R. pomum*, but on *A. arbuscula* or *A. nova*, yielded adults that were similar to *R. calvipomum*, and galls like those of *R. tumidibulla* on *A. arbuscula* were made by a very different species of gall midge not treated further here. It is possible that the salivary secretions of the larvae find a different expression among the different species of *Artemisia*, but it seems more likely that *Rhopalomyia* spp. are closely host specific.

Because we studied material only from southern Idaho and immediate environs, we do not know if our species characterizations are valid throughout the range of *Artemisia tridentata*. As a follow-up of this research it would seem worthwhile to study a few of the commoner galls throughout the range of *A. tridentata* and their presence on other *Artemisia* of the Section *Tridentatae*.

On the other hand it would seem less fruitful and justifiable to pursue further studies such as the present one on other species of *Artemisia*. As a result of this study we know that *Artemisia* gallmakers belong to the subgenus *Diarthronomyia*, we can generally predict their biology, and we can estimate their impact on the host by the location and abundance of the galls. Additional studies could be expected to provide little new, basic information. Also, these gall midges are difficult to distinguish because of the reduction and dearth of characters: considering the number of *Diarthronomyia* present in the world (Gagné 1975) one could conceivably find anatomically similar species that are not at all closely related. Because of these difficulties and unless significant new information is forthcoming, we believe that there is little to gain by giving names in the future to the undoubtedly numerous new species of *Diarthronomyia* associated with *Artemisia* spp. It would be adequate to designate such species found in the course of faunal surveys or other studies simply as "*Rhopalomyia* (*Diarthronomyia*) sp." along with a characterization of its gall.

Taxonomic Characters

Following is a list of characters used in the species descriptions. Only a few are good key characters; most have great ranges of variation and are useful only in combination or under certain circumstances.

Adult Characters:

- Separation of eyes on vertex: the eyes are usually connate but may be separated by a distance of as many as 4 facet diameters.
- Number of antennal flagellomeres and length of necks of flagellomeres III, V, and VII relative to their respective nodes.
- Number of segments and shape of the palpus.
- Shape of labellum: ellipsoid to semicircular.
- Number of setae on frontoclypeus and labellum, and number and sites of setae on palpus.
- Length of wing: an indication of specimen size.
- Number of anepimeral setae.
- Shape of tarsal claws: whether simple or toothed and whether tooth is strong or weak.
- Length of empodia relative to tarsal claws.
- Abdominal setation: number and placement of setae and scales on terga, pleura and sterna. Sternal setae are variable, but basically consist of groups extending across the width of each sternum, and a more cephalic group which is sometimes divided into three subgroups, two lateral and one central. In species with sparse setae, the central group is absent. Located anteriorly on each sternum usually is a pair of trichoid sensilla, but occasionally some species have only one sensillum and others none. Pleural setae are occasionally present and scales more commonly so, but, when present, are usually restricted to the apical abdominal segments.
- Length of ovipositor: this is given as a ratio or the length of tergum VII (as measured from basal trichoid sensilla to base of caudalmost seta on tergum) to that of the more rigid, distal half of the ovipositor.
- Shape of the male genitalia, particularly the shape of the basimere and telomore.

Pupal characters:

The pupa bears some good characters especially in the head armature which is presumably used for breaking out of the galls before the adult emerges. The useful characters are: the shape of the antennal horns, frontal ridges and pronotum, and the length of the pronotal setae.

Key to species of *Rhopalomyia* reared from *Artemisia tridentata* in Idaho

Although females of a few species and most males, if used alone, will run successfully in this key, a male and a pupa or pupal exuviae will be needed in may cases. *Rhopalomyia rugosa* is not keyed here because its male is unknown.

1. Claws toothed, palpus 1- or 2- segmented 2
Claws simple, palpus 1-segmented 18
2. Palpus 2-segmented 3
Palpus 1-segmented 8
3. Trichoid sensilla absent from abdominal sterna . . . .
. . . . *R. pomum* & *R. hirtipomum*
Trichoid sensilla present on at least some abdominal sterna 4
4. Abdominal sternum VII with one trichoid sensillum, remaining sterna
without or with one or two sensillae . . . . *R. calvipomum*
Abdominal sterna II-VII each with 2 trichoid sensilla 5
5. Telomere or male genitalia truncate apically, basimere stout
(Figs. 94-95); pupa with long, conical, antennal horns (Figs. 65-66) . 6

Telomere tapered gradually to apex, basimere narrow (Figs. 90-91);
pupa with short antennal horns (Figs. 67-68, 71-72) 7

6. Abdomen covered with scales; tooth of telomere narrow . . . . *R. nucula*
Abdomen without scales; tooth of telomere wide (Fig. 49) . . *R. obovata*

7. Basimere of male genitalia without a conspicuous dorsal lobe
(Fig. 91); pupal pronotum unmodified (Figs. 67-68) . . . .
. . . . *R. medusa* & *R. medusirrasa* (in part)
Basimere stout, with a large ventral lobe (as in Figs. 92-93);
pupal pronotum produced anteroventrally (Figs. 71-72) . *R. tumidicaulis*

8. Telomere of male genitalia subcylindrical, the tooth narrow
(Figs. 88-89) 9
Telomere ovoid, the tooth wider than long (Figs. 78-79) 10

9. Telomere of male genitalia tapering gradually to apex; pupal pronotum
produced anteroventrally (Figs. 63-64) . . . . *R. mammilla*
Telomere truncate apically (Figs. 88-89); pupal pronotum
unmodified, at least in *culmata* (*anthoides* pupa unknown) . . . .
. . . . *R. culmata* & *R. anthoides*

10. Pupal antennal horn bifid apically (as in Fig. 45) . . . *R. hirtibulla*
Pupal antennal horn with single apical point 11

11. Pupal antennal horns long, conical; frontal projections of pupa
short or absent (Figs. 49-50, 55-56) 12
Pupal antennal horns short; frontal projections strong (as in
Figs. 69-70) 13

12. Abdominal sterna without trichoid sensilla; pupal antennal horns
approximately as long as pronotal setae (Figs. 49-50) . . . *R. tubulus*
Abdominal sterna with trichoid sensilla; pupal antennal horns
much longer than pronotal setae (Figs. 55-56) . . . . *R. lignea*

13. Pupal antennal horn strongly projected ventrally, pronotum
of pupa produced anteroventrally (Figs. 69-70) . . . . *R. hirticaulis*
Pupal antennal horn not projected ventrally, pronotum unmodified . . 14

14. Basimere of male genitalia with prominent ventral lobe (as in Fig. 85) 15
Basimere tapering gradually from base to apex 16

15. Palpal setae clustered near apex . . . . *R. gossypina*
Palpal setae randomly placed . . . . *R. lignitubus*

16. Pupae with prominent frontal protuberances (Figs 67-68)
. . . . *R. medusa* & *R. medusirrasa* (in part)
Pupa with weak or no frontal protuberances (Figs. 57-58, 61-62) . . 17

17. Teeth of tarsal claws strong, occasionally bifid . . . . . . *R. conica*
Teeth of tarsal claws weak, simple . . . . *R. cramboides*

18. Telomere of male genitalia ovoid, the tooth wide 19
Telomere conical or cylindrical, the tooth very narrow 20

19. Abdominal sterna with trichoid sensilla; basimere of male
genitalia with a prominent ventral lobe . . . . *R. florella*
Abdominal sterna without trichoid sensilla; basimere without
a lobe, tapering gradually from base to apex (Figs. 82-83) . . . . . .
. . . . *R. ampullaria*

20. Telomere of male genitalia conical (Figs. 80-81); pupal antennal horn
with a simple apical point and a basal spur (Figs. 51-52) *R. tumidibulla*
Telomere cylindrical, truncate apically (Figs. 76-77); pupal antennal
horn bifid, without an apical spur . . . . *R. brevibulla*

Rhopalomyia pomum Gagné

(Figs. 1, 2, 3, 4, 5, 6, 7, 73, 74, 75)

Rhopalomyia artemisiae (Felt) 1908:339, (nec *R. artemisiae* (Bouché) 1834.
Rhopalomyia pomum Gagné 1975:483 (new name for *artemisiae* Felt).

Diagnosis

Rhopalomyia pomum is one of a group of larger sagebrush midges that have 2-segmented palpi and toothed claws. It is very close to R. hirtipomum and R. calvipomum, which form the same general type of gall. The external anatomy of R. hirtipomum appears identical with R. pomum, but its gall has a very fuzzy surface and is always monothalamous. The adult differs from R. calvipomum by lacking trichoid sensilla at the cephalic end of most of the abdominal sterna, and the pupa has simple rather than bifid antennal horns.

Description

Male. Wing length, 2.6 - 3.1 mm. Eyes usually less than one facet diameter apart at vertex. Antenna 15-16 flagellomeres; neck flagellomere III, 0.53-0.59 length node; neck V, 0.60-0.72 length node; neck VII, 0.60-0.71 length node. Fused labella hemispherical in frontal view, 0-6 setae per labellum. Palpus 2-segmented, segment II usually about 0.5 length I, occasionally as long; 0-3 setae present per segment, scattered when present. Frontoclypeus with 3-11 setae per side. Anepisternum with 5-15 setae. Claws toothed, the teeth occasionally bifid. Empodia as long as claws. Abdomen: tergum III with 15-23 setae per side, V with 18-30, VI with 21-35, and VIII with 19-32, the caudal groups on all terga except VII and occasionally VIII not joined mesally; pleura I-IV without setae, V-VI with 0-2, VII with 1-8, and VIII with 5-13, occasional scattered scales sometimes present on distal segments; sterna without basal trichoid sensillae, sternum VII with 32-57 setae in distal groups and 28-50 in basal group, the latter usually separated into a mesal and two lateral groups. Genitalia (Figs. 73-75): basimere with prominent ventral lobe; telomere ovoid, tapering gradually to wide apical tooth; sternum X usually weakly bilobed.

Female. Wing length, 1.8-2.1 mm. Antenna with 14-16 flagellomeres; neck flagellomere III, 0.11-0.29 length node; neck V, 0.05-0.25 length node; neck VII, 0.00-0.30 length node; necks absent beyond V-IX. Other head and thoracic characters as in male. Abdomen: tergum III with 11-20 setae per side, V with 19-29, and VII with 12-23, the two groups on VII usually convergent mesally; pleura I-V without setae, VI with 0-4 setae, VII with 2-10, occasional scales sometimes present on distal segments; sterna without trichoid sensillae, sternum VII with 20-38 setae in distal group, 10-41 in basal, these usually disposed in the 3 groups, 1 mesal and 2 lateral; tergum VII 0.27-0.34 length distal half of ovipositor; setulae of the latter elongate, few pronged.

Pupa (as in Figs. 47-48). Antennal horn short, with a single point. Frons with pair of pointed, bilaterally compressed projection laterad of the clypeal base.

Lectotype here designated, male, #3120, emerged VI-16-1883, Fort Garland, Colorado, Artemisia tridentata, C 989, USNM Type No. 29260. Paralectotype, female, same data as lectotype.

Felt's type series, which does not include gall material is arbitrarily assigned to R. pomum rather than R. hirtipomum These two species cannot be distinguished on the basis of adults. However, inasmuch as galls of R. pomum are much more commonly found in nature and thus adults of this species were more likely to have been before Felt when he described D. artemisiae, we believe our action is justifiable.

Galls typical of those of R. pomum were taken from A. arbuscula, nova, cana, and tripartita. Rhopalomyia specimens were reared from the first two plant species, but are different from R. pomum in that they have trichoid sensilla on the abdominal sterna.

Biology

Egg. The bright-red eggs were found in masses on the surface of developing persistent leaves between two unseparated leaves in the bud (Fig. 1) and on the inturned margins of a more developed leaf. Eight egg masses contained from 26-208 eggs (avg. 100.3). The dimensions of 84 eggs ranged from 0.18-0.29 mm in length (avg. 0.25) and 0.05-0.10 mm in width (avg. 0.08). At Site 1 eggs were evident from May 8 to 28, 1969, but could not be found on June 13. This suggests an ovipositional period of at least 20 days and a developmental period for individual eggs of less than 16 days.

Larva. Larvae were found at Site 1 from mid-October (coinciding with the first signs of gall) until mid-May. At the higher elevation Sites 2 and 3, they were also found in mid-October, but were still evident until the last of May.

Pupa. Pupae were observed in the field 15 days prior to the first observed adult emergence at Site 1, in 1969. Nine mature female pupae were found to contain 240-511 eggs (avg. 369.8).

Adult emergence. The monothalamous galls were the first to show midge emergence. Under field conditions emergence occurred as early as May 7, 1969 at Site 1 when a few fresh pupal exuviae were found. On May 28 some pupae were present at this site indicating that emergence was still in progress, but it was completed sometime prior to June 13. Examination of galls at Site 3 at a higher elevation showed that adult emergence had commenced no more than a few days prior to May 19, 1969. The host plants were at the same stage of seasonal development at all sites during midge emergence with the persistent leaves beginning to separate in the bud.

In the laboratory the earliest emergence of adults was on April 23, 1969 from galls collected on April 14 from A. t. tridentata at Site 20 at an elevation of 3140 feet. The latest seasonal rearing was July 2, 1968 from galls collected on June 25 from A. t. vaseyana f. spiciformis at Site 10 at an elevation of 6500 feet.

In all rearings of this species, more females emerged than males. Individual rearings of 182 similar apprearing polythalamous galls from Sites 1-4 also had a preponderance of galls with only one sex (Table 3). Females (Fig. 1) emerged from 57.1% of the galls, whereas males (Fig. 2) emerged from 23.1%. Only 5.5% of the 182 galls had emergence of both males and females. No midge emergence occurred from the remaining 14.3% of the galls although parasitoids emerged from 23 of these 26 galls. Midge emergence occurred daily but only during the evening or early morning hours. Maximum emergence from an individual gall showed no great difference between the sexes. During a period of 14 days a total of 59 males emerged from 1 gall and during an 8 and 13 day period a total of 51 females emerged from each of two galls.

Caging studies to determine the specificity of R. pomum and galls were not successful. Midges emerging from polythalamous galls were caged on 18 plants; however, only 3 of these plants survived the summer after transplanting. One of these, an A. t. vaseyana plant, did subsequently form eight polythalamous and five monothalamous galls. These galls appeared the same as those caused by this midge species under normal field conditions. No galls were found on the other two surviving plants.

Daily activity begins with emergence of the adult from the gall. Although male emergence was not observed in the field, specimens were found at first light clinging to foliage indicating a possible predawn emergence. Female emergence begins before sunrise in early light. It is first evident when the dark head of the pupa breaks through the gall surface. The pupa works through the surface until half its body is protruding. A longitudinal split down the dorsal surface of the thorax then occurs through which the female emerges. The pupal exuvium (Fig. 3) remains attached to the gall. The female then crawls to a nearby leaf or stem where the wings expand and dry. During this period the ovipositor remains fully extended.

The entire process of emergence was recorded for two individuals at Site 1 on May 11, 1969. The sequence of events and recorded time were as follows: pupal head broke through gall surface, 0700 and 0750; thoracic split occurred, 0720 and 0801; adult completely emerged, 0728 and 0807; and wings expanded, 0735 and 0810. Thus it took a total of 35 and 20 minutes respectively for these individuals to complete emergence.

Male flight. Each morning, flight of newly emerged males coincides with emergence of the first females. The males usually appear as a large group, but occasionally only a few individuals or single specimens are present. The groups are associated with gall bearing sagebrush plants and move from one portion of a plant to another or to other plants in search of females. The searching flight appears to be concentrated about branches with or in the proximity of galls.

Table 3. Sex variation in Rhopalomyia pomum from polythalamous galls collected from four sites in Twin Falls Co., Idaho, 1969.

		Galls with emergence of			Galls with
Site	No. of Galls	Females only	Males only	Both Sexes	No Emergence
1	50	32	13	2	3
2	32	14	3	2	13
3	50	33	10	1	6
4	50	25	16	5	4
Totals	182	104	42	10	26
Percent		57.1	23.1	5.5	14.3

Activity of males as indicated by trap-board counts (Table 4) taken at Sites 2, 3 and 4 generally shed an increase after 0700 and a decrease after 0800. These counts indicate a relationship between male activity and temperature and light which was further indicated by observations. Very few males were observed in the later morning hours. They usually displayed a behavioral pattern consisting of frequent resting periods on foliage that lasted up to 20 seconds between periods of flight. Male flight behavior also was affected by wind during the two trapping periods at Site 4 when gusty conditions prevailed. Males flew between gusts and either rested on foliage or crawled about seeking females during gusts. Hourly wind recordings could not be correlated with the trapping results due to the variability of the wind velocities during each hour of a morning.

Mating. Females are ready to mate only when their wings are fully expanded. Teneral females discourage or prevent mating by body movement or by holding their genitalia against the plant surface. The female, if not mated within 5-15 minutes after becoming receptive, crawls to another or more exposed place on the plant. She mates only once. Mated females can be recognized by having the ovipositor retracted and are usually found in less exposed places. Males occasionally were observed attempting to copulate with mated females but were unsuccessful because of movement of such females.

The male locates a receptive female during the course of a searching flight. Upon locating such a female he hovers over her briefly before mounting. In the copulatory position the head and thorax of the male are situated over the abdomen of the female and the male's abdomen is curved downward directly over or to the side of the female with their genitalia in contact. The pro- and mesothoracic legs of the male clasp the female while the metathoracic pair are in contact with the plant or extend in space. After mating a male resumes the searching flight.

Most males quickly attained the copulator position. When difficulty was encountered a male either departed or attempted to mate again. One male was observed trying to mate with the head of a female and on the side of her thorax. After much activity on the part of both individuals, the male flew a short distance, but returned immediately and then successfully mated. In another case a second male attempted to position himself on a mating pair. In still another case four males in succession attempted to mount a female being carried off by a worker harvester ant, Pogonomyrmex owyheei Cole.

Observation of 34 pairs in copulation showed that copulation lasted from 20-35 seconds (avg. 27.5) under calm conditions. Under windy conditions four mating pairs required 35-45 seconds (avg. 41.3) for copulation.

Oviposition. Females oviposit about three hours after copulation. With a now partially extended ovipositor the female crawls up a stem in search of leaf growth where she backs into a bud with developing persistent leaves. The ovipositor is then fully extended and, after some testing and probing, eggs are deposited or the female departs to locate another bud. In one instance a female was observed "testing" a bud, then partially retracted her ovipositor and left, apparently because eggs were already present on the bud. Observations indicate that only after initial oviposition does the female fly to other branches or to other plants. By 1100 few females could be found on the plants although trapping records (Table 3) indicate continued activity after this time. With flight females become difficult to observe.

The number of eggs in nine virgin females ranged from 263-539 (avg. 410.7).

Gall

Description and development. This persistent leaf series gall is either monothalamous or polythalmous. The mature form varies from globose to distinctly irregularly lobed. The surface of the monothalamous galls is uniform while that of the polythalamous galls (Fig. 3) has both deep and shallow fissures giving the gall a lobed appearance. The color ranges from reddish to a common pattern of mottled reddish and greenish to completely green. The surface is covered with short trichomes. Often, monothalamous and polythalamous galls are present on the same plant (Table 5) with the latter usually predominatory. A total of 1185 galls (1166 polythalamous and 19 monothalamous) occurred on a sampled plant at Site 2.

Under the surface layer the gall consists of a spongy mass of interwoven fibers. Within this fibrous mass near the base of the gall are the sclerenchymatous larval capsules. A single fiber extends from the upper portion of each capsule to a small brown spot on the gall surface (Fig. 4).

One hundred fifty galls had a range of 13-45 mm (avg. 26) for their greatest diameter across the gall from its base. An opposing diameter at the widest point perpendicular to this diameter ranged from 12-40 mm (avg 20).

Table 4. Numbers of Rhopalomyia pomum adults entrapped hourly in relation to temperature and relative humidity for 2 days at Sites 2, 3, and 4, Twin Falls Co., Idaho, 1969.

Date	Recording	0600	0640	0700	0800	0900	1000	1100	1200	1300
Site 2										
22 May	Males	--	--	14	115	62	2	1	0	--
	Females	--	--	0	0	0	1	8	5	--
	Temperature (°F)	42	--	48	58	65	71	72	77	--
	Relative Humidity (%)	77	--	67	51	39	33	31	26	--
23 May	Males	--	--	43	53	7	1	0	0	--
	Females	--	--	0	2	2	10	8	4	--
	Temperature (°F)	48	--	55	68	72	76	79	82	--
	Relative Humidity (%)	66	--	59	42	38	31	31	28	--
Site 3										
26 May	Males	--	165	--	45	14	3	0	0	0
	Females	--	0	--	0	0	10	4	5	1
	Temperature (°F)	55	55	--	64	68	73	74	75	--
	Relative Humidity(%)	43	43	--	34	31	29	23	24	--
27 May	Males	--	85	--	98	8	1	0	0	--
	Females	--	0	--	0	1	1	0	8	--
	Temperature (°F)	55	58	--	59	57	62	63	66	--
	Relative Humdity (%)	43	46	--	42	45	41	42	36	--
Site 4										
29 May	Males	--	--	18	28	4	4	0	0	--
	Females	--	--	0	0	0	1	1	0	--
	Temperature (°F)	47	--	48	57	62	73	75	75	--
	Relative Humidity(%)	40	--	41	35	36	19	24	24	--
2 June	Males	--	--	19	29	2	0	0	0	--
	Females	--	--	0	0	0	1	1	0	--
	Temperature (°F)	48	--	50	59	68	73	77	76	--
	Relative Humidity (%)	54	--	49	47	34	32	26	25	--

Developing galls appear as small irregular swellings on either surface of a persistent leaf (Fig. 5). They have a dense covering of trichomes which gives them a gray color except for small brown spots on the surface which are free of trichomes. The galls were first observed on October 23, 1969 at Sites 1, 2 and 3. On March 18, 1970 an increased swelling of some galls was noted (Fig. 6) while all others appeared unchanged. At this date no ephemeral leaf development was evident.

Seasonal development was followed only at one location. At Site 1 greatest gall growth occurred during April with maximum size being attained by the end of the month. At this time the first whorl of ephemeral leaves was as long as the persistent leaves, stem growth was becoming apparent, and the galls were conspicuous. Later in May when midge emergence took place the galls and the persistent leaves had begun to dry and then were shed during July and August. However, galls in the more sheltered portions of the crown persisted for a year or more. Observations at other sites indicated that seasonal development varies with elevation.

Effect on the plant. At four sites where galls were abundant they were distributed throughout the plant crown (Table 5). The density of plants varied between these sites and some plants had few if any branches on certain sides. Plants at Site 4 were quite close with side branches touching those of neighboring plants while plants at the other sites were farther apart. Formation of a monothalamous gall affected only the one persistent leaf while formation of the polythalamous galls damaged the buds from which 31.02% of the galled leaves originated. This damage (Figs. 3, 7) resulted in distorted ephemeral leaves and a lack of stem growth. No plant or branch mortality was found to be the direct results of this gall formation.

Associated insects

Curculionidae: Apion sordidum Smith, commonly reared from galls, proved to be an inquiline. The larvae of this small dark weevil mine through the fiber mass and pupate in the gall. In rearing containers adults emerged at the same time as the gall midges or within a week after. One to several emerged from individual galls. They do not have any apparent adverse effect on the midges.

Nabidae. Early instar nymphs of *Reduviolus alternatus* Parshley were found in most plant materials after a few days in rearing. Six individuals were reared and were observed preying on midge pupae as they broke through the gall surface.

Formicidae. The harvester ant, *Pogonomyrmex owyheei* Cole, appeared to be a major predator of the adult midges.

Platygasteridae. Two species, *Platygaster utahensis* (Ashmead) and *Platygaster* sp. A. were reared from galls. The hosts of these parasitoids were not identified.

Chalcidoidea. The following parasitoids were commonly reared from galls. *Torymus aeneoscapus* Huber, *Tetrastichus* sp. and a species of Miscogasterinae. Their hosts were not identified.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bannock Co: .5 mi W McCammon, 4719 ft; Bear Lake Co: 3 mi N Georgetown, 6200 ft (specimen reared); Bingham Co: 15 mi NW Blackfoot; Blaine Co: 3 mi W Carey, 5150 ft (specimens reared); Boise Co: 7 mi S Horseshoe Bend, 4200 ft; 20 mi S Idaho City (specimens reared); Butte Co: 21 mi SW Arco, 6000 ft; 18 mi NE Howe, 5100 ft; Caribou Co: 2.5 mi E Wayan, 6750 ft; Cassia Co: 8 mi SE Albion, 5350 ft; 4 mi W Almo, 6300 ft

Table 5. Abundance, distribution, and impact of Rhopalomyia pomum galls on five plants at four study sites in Twin Falls Co., Idaho, 1969.

			Crown Diameter		Number of Galls					Total		Destroyed
Site	Plant	Height	Wide	Narrow	North	East	South	West	Center	Poly[1]	Mono[2]	Bud
1	#3	54	86	56	97	30	32	27	111	235	62	123
	5	62	97	89	40	72	52	63	80	205	102	83
	6	62	93	73	14	33	111	NB	186	232	112	71
	7	47	86	62	22	67	38	22	55	94	120	40
	9	52	64	55	49	74	37	2	15	32	145	14
2	#1	89	82	36	34	320	415	109	307	1166	19	283
	3	84	97	67	39	118	92	23	92	336	28	99
	5	71	58	37	NB	70	61	6	198	334	1	159
	6	61	59	38	13	2	4	18	23	53	2	17
	9	59	63	38	47	197	NB	16	227	483	4	144
3	#1	41	51	47	254	148	54	76	186	633	85	142
	3	32	45	29	12	NB	9	4	47	71	1	35
	5	38	42	34	26	15	23	4	57	115	10	37
	6	44	56	29	32	9	6	20	10	67	10	20
	10	35	42	28	3	12	3	9	8	34	1	9
4	#1	49	47	26	0	NB	0	0	14	14	0	1
	3	62	72	34	0	0	0	2	41	37	6	15
	5	58	54	26	0	0	0	0	16	15	1	1
	6	49	44	39	0	1	1	0	20	17	5	6
	9	54	64	56	10	31	1	1	39	72	10	18

NB - No branches in quadrant, [1]Polythalamous Galls, [2]Monothalamous Galls.

(specimen reared); 2.5 mi SE Basin, 4200 ft; 8 mi SE Malta, 4400 ft; Clark Co: 4 mi NE Argora, 7250 ft; 3.5 mi W Dubois, 5150 ft; 8 mi N Small, 5960 ft; Custer Co: 4 mi SW Clayton, 5000 ft; Elmore Co: 22 mi N Mt. Home, 4700 ft (specimens reared), 6 mi. W Hill City, 5400 ft; Franklin Co: 1.5 mi W Dayton, 4750 ft (specimens reared); Gooding Co: 5 mi W Hagerman (specimens reared); Lemhi Co: 1.5 mi E and 3 mi NE Baker; Lincoln Co: 4 mi W Dietrich, 4000 ft; 25 mi N Shoshone, 4960 ft; 5 mi NE Shoshone, 4700 ft (specimens reared); Madison Co: 9 mi W Rexburg, 4850 ft; Oneida Co: 6 mi N Stone; Owyhee Co: 6 mi S Grasmere, 5450 ft; 20 and 28 mi SW Marsing; 3 mi E Reynolds; 14 mi S Riddle, 5300 ft; Power Co: 14 mi W American Falls, 4400 ft; Twin Falls Co: 11 mi NW Buhl; 18 mi E Rogerson 5700 ft. (specimens reared); 8 mi SW Rogerson, 6200 ft. Lower Rock Creek Canyon (specimens reared); Washington Co: 4 mi N Midvale, 2544 ft. NEVADA: Washoe Co: 12 mi SW Reno.

A. *tridentata tridentata*: IDAHO: Butte Co: .5 mi W Arco, 5300 ft; Franklin Co: 1 mi W Dayton, 4700 ft (specimens reared); Gooding Co: 3 mi SE Bliss, 3140 ft (specimens reared); 9 mi W Bliss, 3000 ft (specimens reared); 515 mi E Gooding, 3800 ft; Lemhi Co: 3.5 mi E Leadore, 5850 ft; 16 mi N Salmon, 4000 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft (specimens reared); 10.5 mi NE Richfield, 4700 ft. (specimens reared); Minidoka Co: 2 mi E Acequia, 4200 ft. (specimens reared); Owhyhee Co: 2 mi W Indian Cove, 2850 ft; Grasmere, 5126 ft; 4 mi NW Murphy, 2800 ft; 2 mi S Riddle, 5300 ft; Twin Falls Co: 6 mi S Bliss, 11 mi S Hansen, 4300ft (specimens reared); 6 mi NE Twin Falls, 3700 ft; 5 mi E Twin Falls, 3746 ft (specimens reared); 5.5 mi E Twin Falls 3650 ft (specimens reared); 23 mi SW Twin Falls, 4950 ft (specimens reared); MONTANA: Beaverhead Co: 6 mi E Bannock Pass Summit; 12 mi E Bannock Pass Summit; 17 mi E Bannock Pass Summit; WASHINGTON: Franklin Co: Palouse Falls State Park.

A. *tridentata vaseyana*: IDAHO: Blaine Co: above Galena Summit, 8900 ft (specimens reared); 15 mi NW Ketchum, 7500 ft; 6 mi S Ketchum, 5500ft (specimen reared); Camas Co: 5 mi N Fairfield, 5150 ft; 9 mi N Fairfield, 6000 ft; 12 mi S Fairfield, 5450 ft; Cassia Co: Elba-Basin Pass Summit; 8 mi W Elba, 6350 ft; 7 mi E Oakley; Custer Co: 5 mi NW Galena Summit, 7350 ft (specimens reared); 8 mi NW Mackay, 6200 ft (specimens reared); Pass Creek Summit 7633 ft; 2 mi S Stanley, 6100 ft (specimens reared); Gooding Co; 16 mi N Gooding, 5225 ft; Franklin Co: 3 mi W Dayton 4800 ft (specimens reared); Oneida Co: 9.5 mi W Malad 5200 ft (specimens reared); 11 mi W Malad; Owyhee Co: 2 mi N Riddle, 5400 ft (specimens reared); 6 mi N Riddle, 5500 ft; 7 mi E. Sheaville, Oregon (specimens reared); Twin Falls Co: 15 mi S Hansen, 4525 ft; 17 mi S Hansen, 4725 ft (specimens reared) 21 mi S Hansen, 5240 ft; 22 mi S. Hansen, 5700 ft (specimens reared); Magic Mt. Ski Area, 6400 ft; 17 mi E Rogerson, 5700 ft; Valley Co: 6 mi N Cascade, 4700 ft; MONTANA: Beaverhead Co: 1.7 mi E Bannock Pass Summit

A. *tridentata vaseyana* f. *spiciformis*: IDAHO: Camas Co: 11 mi N Fairfield, 6500 ft (specimens reared); 13 mi N Fairfield, 7000 ft.

Rhopalomyia hirtipomum Gagné, new species

(Figs. 9, 10, 47, 48)

Diagnosis

Rhopalomyia hirtipomum appears to be anatomically identical to *R*. *pomum* but is responsible for a slightly different gall. That of *hirtipomum* is densely covered with long trichomes, whereas that of *R*. *pomum* has short, prostrate, sparse trichomes on the surface. In addition, galls of the former are always monothalamous.

Description

Essentially as for R. pomum. Male genitalia as in Figs. 73-75; pupal head (Figs. 47-48).

Holotype, male, 1.2 mi W Washtucna, Adams Co., Washington, IV-16-1968, Artemisia tridentata tridentata, R. G. Jones, USNM Type No. 66624.

Biology

Seasonal occurrence. Overwintering immature larvae were collected on October 23, 2969 and mature larvae on April 23, 1969 at Site 1 from A. t. wyomingensis. Emergence of adults in the field was evident on April 28, 1970 at Sites 21 and 22 when both pupae and exuviae were found. In the laboratory, emergence occurred on April 19 and 20, 1969 from A. t. vaseyana f. xericensis galls collected on April 8 at Site 27. Midges emerged also on April 20 and 21, 1969 from A. t. wyomingensis galls collected on April 14 and on April 23, 1969 from galls collected on April 21 at Site 21.

Gall

Description and development. This monothalamous gall (Fig. 9) is globose and quite similar to the monothalamous gall of R. pomum. However, the gall surface is densely clothed with long trichomes, giving it a fuzzy appearance. The gall is generally solitary on either the upper or lower leaf surface, but can occasionally be found in confluent clumps (Fig. 10). Fifty-nine mature galls were measured: the diameter extending from the gall base ranged from 8-15 mm (avg. 12) and the diameter perpendicular to this ranged from 8-13 mm (avg. 11).

Developing galls were first found on October 23, 1969 at Site 1 on A. t. wyomingensis. They appeared as fuzzy swellings with diameters of 1-3 mm on a persistent leaf surface. The long, dense trichomes were white, while the surface of the gall was reddish. Galls had the same appearance on A. t. vaseyana f. xericensis when found at Site 27 on December 29, 1969. At both sites this appearance persisted until March, when growth resumed. As the gall grew, their surface coloration gradually changed to gray. Maximum size of the gall was found to coincide with the presence of pupae and with new stem growth of approximately 2.5 cm in length. Shedding of the galls occurred in July and August, at the same time as those of R. pomum.

Effect on the plant. There was no apparent detrimental effect observed from galls of this species.

Associated insects

Curculionidae. Apion sordidum is an inquiline in the gall of this midge species. It was reared from galls at most study sites.

Chalcidoidea. Torymus aeneoscapus and Tetrastichus sp. were reared commonly from galls collected at all study sites.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bear Lake Co: 9 mi S Dingle, 6300 ft; Cassia Co: 6 mi W Burley, 4240 ft (specimen reared); Owyhee Co: 27 mi S Bruneau, 4640 ft; Power Co: 4 mi W American Falls, 4400 ft; Twin Falls Co: 23

mi SW Twin Falls 4950 ft.

A. *tridentata* *tridentata*: IDAHO: Owyhee Co: 23 mi SW Grandview (specimens reared); WASHINGTON: Adams Co: 1.2 mi N Washtucna (holotype, male and male and 2 females, paratypes).

A. *tridentata* *vaseyana* f. *spiciformis*: IDAHO: Camas Co: 13 mi N Fairfield, 7000 ft.

A. *tridentata* *vaseyana* "f. *xericensis*": IDAHO Washington Co: 8 mi N Weiser, 2580 ft (specimens reared).

A. *tridentata* *wyomingensis*: IDAHO: Gooding Co: 9 mi W Bliss, 3000 ft (2 females, 2 pupae, 2 pupal exuvia; paratypes); 3 mi S Hagerman, 2964 ft (3 males, 3 females, paratypes); Lincoln Co: 12 mi W Kimama, 4275 ft; Twin Falls Co: 5 mi E Twin Falls, 3746 ft; Balanced Rock (specimens reared); 1 mi E Balanced Rock (male, paratype); Owyhee Co: 13 mi SE Murphy (2 females, 2 pupal exuvia, paratypes); Owyhee Co: 4 mi NE Reynolds (male, 5 females, 8 pupae, paratypes).

Rhopalomyia *calvipomum* Gagné, new species

(Figs. 8, 45, 46)

Diagnosis

This species is most similar to *R*. *pomum* and *R*. *hirtipomum*. Unlike those two species, adults of *R*. *calvipomum* have basal trichoid sensilla on the abdominal sterna and pupae have bifid antennal horns. All three species form the same general type of gall, but that of *R*. *calvipomum* is naked.

Description

Male. Wing length, 2.5-3.1 mm. Eyes closely approximate at vertex, usually less than 1 facet diameter apart. Antenna with 15 flagellomeres; neck flagellomere III, 0.57-0.60 length node; neck V, 0.61-0.70 length node; neck VII, 0.60-0.69 length node. Fused labella hemispherical in frontal view, sometimes indented mesally, 0-4 setae per labellum. Palpus 2-segmented, the segments subequal in length but II usually narrow; segment I with 2-4 setae, segment II with 0-2. Frontoclypeus with 6-16 setae per side. Anepisternum with 9-15 setae. Claws unidentate. Empodia as long as claws. Abdomen: tergum III with 17-22 setae per side, V with 19-30, VII with 25-35, and VIII with 21-30, the 2 groups on segments VII and VIII contiguous mesally; pleura I-III without setae, IV with 0-2, V with 0-3 and VI with 2-6 and VII and VIII with 6-15; sterna II-VI usually with trichoid sensillum, occasionally 1 or more sterna without or with 2, sternum VII with 1, VIII with none; sternum VII with 37-45 setae in distal group, 28-54 in basal group, these continuous across the sternum. Genitalia as for *R*. *pomum* (Figs. 73-75).

Female. Wing length, 1.7-2.1 mm. Antenna with 14-15 flagellomeres, neck flagellomeres III, 0.15-0.19 length node; neck V, 0.14-0.18 length node; neck VII, 0.07-0.14 length node; necks not present beyond VII or VIII. Other head and thoracic characters as in male. Abdomen: tergum III with 10-14 setae per side, V with 23-37, and VII with 22-27, the two lateral groups on VII almost contiguous mesally; pleura without setae on segments I-IV, pleura V-VI with 1-4, VII with 6-13. Sterna II-VI usually with one trichoid sensillum, occasionally 0-2; sternum VI with 1, rarely no trichoid sensillum, in which case preceding sternum with 1; sternum VII with 26-40 setae in distal group and 23-50 in basal group, the latter generally divided in 2 lateral and 1 mesal group; tergum VII 0.33-0.36 length distal half of ovipositor, the latter with elongate, few pronged setulae.

Pupa (Fig. 45-46). Antennal horn bifid, the mesal point slightly shorter than the lateral and usually hidden in side view. Frons with single pair of pointed, bilaterally compressed projections.

Holotype, male, 5 mi E Twin Falls, Twin Falls Co., Idaho, IV-14-1969, Artemisia tridentata tridentata R. G. Jones, USNM Type No. 66625.

Biology

Seasonal occurrence. Immature larvae were found in newly evident galls or A. t. wyomingensis at Site 21 on March 23, 1970. Mature larvae were present at Site 1 on May 9, 1969 on A. t. wyomingensis and at Site 17 on July 11, 196 on A. t. vaseyana f. spiciformis. Collections of pupae were made on May 14, 1969 from A. t. wyomingensis at Site 1 and on July 11, 1969 from A. t. vaseyana f. spiciformis at Site 17. In the field, adult emergence from A. t. wyomingensis was underway on June 1, 1970 at Site 1 and 16 when both pupae an pupal exuviae were found. Emergence was completed the previous year at Site 1 before May 28. In 1970 emergence at Site 27 from A. t. vaseyana f. xericensi was completed sometime prior to June 2.

Gall

Description and development. The mature gall (Fig. 8) is globose t irregularly elongate and is similar to that of R. pomum in shape and by havin small brown spots on the surface. It differs by being firmer and having smooth surface that lacks trichomes.

One hundred fifty mature galls were measured: the diameter extending fro the gall base ranged from 9-26 mm (avg. 15) and the diameter of the greatest width perpendicular to the previous mesaurement ranged from 8-20 mm (avg. 13).

Developing galls were evident on March 23, 1970 at Site 21. They appeare as a reddish or violet-colored swelling of a persistent leaf. At this time stem growth had not begun but the first whorls of ephemeral leaves were developing and expanding. Maximum size of the gall was found to coincide wit the presence of pupae and with new stem growth approximately 7.5 cm i length. Galls fall from the plant in July and August, as do those of R. pomum.

Effect on the plant. Initiation of gall formation causes a deformation o leaf growth and prevents stem development at the given bud. At sites where abundant, the galls were found throughout the crown of all host plants, but n plant or branch mortality was evident.

Associated insects

Curculionidae. Apion sordidum was reared from galls at most study sites.

Platygasteridae. Platygaster utahensis and Synopeas sp. were reared fro galls collected from Site 17 on A. t. vaseyana f. spiciformis.

Chalcidoidea. Several undetermined species of Tetrastichus were commonl reared from galls at nearly all study sites.

Host plants and distribution of specimens studied

Artemisia tridentata. IDAHO: Bear Lake Co: 9 mi S Dingle, 6300 f (specimen reared); Boise Co: 7 mi S Horseshoe Bend, 4200 ft; Cassia Co: 8 m SE Albion, 5350 ft; Clark Co: 20 mi NW Terreton, 4800 ft (specimen reared)

Custer Co: 5 mi E Clayton, 5650 ft; 32 mi NW Mackay; Lincoln Co: 4 mi N Dietrich, 4100 ft (specimens reared); Owyhee Co: 40 mi SE Bruneau; Teton Co: 3 mi S Driggs, 6150 ft (specimens reared); Twin Falls Co: 11 mi S Hansen, 4300 ft. NEVADA: Elko Co: nr. Dinner Station, Virgil Delegans (specimens reared, V-14-1969; 1 male, 5 females and 2 pupae, paratypes).

A. tridentata tridentata: IDAHO: Owyhee Co: 23 mi SW Grandview; Ada Co: 5 mi SE Boise (pupa, paratype).

A. tridentata vaseyana f. *spiciformis*; IDAHO: Franklin Co: 28 mi NE Preston, 6850 ft (specimens reared, VII-11-1968; 4 females and 2 pupae, paratypes).

A. tridentata vaseyana "f. *xericensis*": IDAHO: Washington Co: 8 mi. N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Canyon Co: 15 mi S Nampa, 2500 ft; Elmore Co: 7 mi S Mt. Home, 3000 ft (specimens reared IV-21-1968; male and pupa, paratypes) 3 mi N Mt. Home, 3325 ft (specimens reared IV-21-1968; 3 males and 4 females, paratypes); Gooding Co: 9 mi W. Bliss, 3000 ft (4 pupae, paratypes); 3 mi S Hagerman, 2964 ft (pupa); Lincoln Co: 12 mi W Kimama, 4275 ft; Twin Falls Co: 5 mi E Twin Falls, 3746 ft (specimens reared V-14-1969; holotype, male, and 10 males, 10 females, 13 pupae, paratypes); 23 mi SW Twin Falls, 4950 ft; NE Balanced Rock (pupa).

Rhopalomyia tubulus Gagné, new species

(Figs. 11, 49, 50)

Diagnosis

The pupa of this species is similar to that of *R. obovata* and *R. nucula* except that its frontal projections are not as strong. Adults can readily be separated from those of the above two species by the 1-segmented palpus and the lack of basal trichoid sensilla on the abdomenal sterna.

Description

Male. Wing length, 2.3-2.5 mm. Eyes contiguous at vertex. Antenna with 14-15 flagellomeres; neck flagellomere III, 0.47-0.53 length node; neck V, 0.43-0.52 length node; neck VII, 0.47-0.58 length node. Labella apparently not fused, ellipsoid-angular in frontal view, 1-2 setae per labellum. Palpus 1-saegmented, elongate-ovoid, occasionally pointed apically, with 0-3 setae. Frontoclypeus with 3-4 setae. Anepisternum with 3-7 setae. Claws toothed, the teeth strong. Abdomen: tergum III with 7-9 setae per side, V with 8-11, VII with 11-16, and VIII with 8-12, the groups not contiguous mesally; pleura without setae but with many scales; sterna II-VIII without trichoid sensilla, sternum VII with 26-30 setae in distal group, 31-38 in basal. Genitalia: basimere with short basoventral lobe, telomere elongate-ovoid, tapering gradually from midlength to toothed apex.

Female. Wing length, 1.4-1.8 mm. Antenna with 14-15 flagellomeres, none with necks. Other head and thoracic characters as in male. Abdomen: tergum III with 8-11 setae per side, V with 9-17, and VII with 7-13, setal groups of terga not contiguous mesally; pleura without setae but with many scales; sterna II-VII without trichoid sensilla, sternum VII with 16-26 setae in distal group and 14-29 in basal, the latter either continuous across its sternum or separated into two lateral groups; tergum VII 0.36-0.38 length distalhalf of ovipositor.

Pupa (Figs. 49-50). Antennal horns long, conical, tapering gradually from base to pointed apex. Frons with two pairs of projections: a pair of transverse ridges immediately caudad of the antennal bases, the anterior surface concave, the posterior convex; and a pair of pointed, bilaterally compressed projections laterad of the base of the clypeus.

Holotype, male, 9 mi W Bliss, Gooding Co., Idaho, IV-14-1969, Artemisia tridentata, R. G. Jones, USNM Type No. 66626.

Biology

Seasonal occurence. Adults were reared on April 24, 1969 from galls collected April 14 at Site 21 and from May 15-19, 1969 from galls collected May 14 at Site 1.

Gall

Description and development. The mature gall is tube-shaped (Fig. 11). The surface is dark reddish and covered with the same white trichomes as on the normal leaf surface. The gall has a single larval chamber at the base, is hollow in the center and has a thin septum near the apex. The hollow portion is utilized by the pupa to facilitate escape, with the pupal exuvium remaining at the ruptured apical septum.

In appearance the developing gall differs only in size from that of the mature gall. Developing galls were found on March 23, 1970 at Site 21 on A. t. wyomingensis and on March 24 at Site 27 on A. t. vaseyana f. xericensis. All observable growth occurs during the spring with maximum size of the galls coinciding with the presence of pupae.

Twenty-three mature galls ranged in length from 2-6 mm (avg. 4.5) with diameters ranging from 1-2 mm (avg. 1.4).

Effect on plant. Galls were not abundant. Their formation affected only a small portion of an individual persistent leaf with no observable adverse effects.

Associated insects

Chalcidoidea. Tetrastichus sp. was reared from galls of R. tubulus and established as a parasitoid of this midge species.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Cassia Co: 6 mi W Burley, 4240 ft (female and pupa paratypes).

A. tridentata vaseyana "f. xericensis": IDAHO: Washington Co; 8 mi N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt Home (pupa paratype); Gooding Co: 9 mi W Bliss, 3000 ft (holotype and male and 2 pupal exuviae, paratypes); Owyhee Co: 3 mi SW Walter's Ferry (9 males and 8 females, and 5 pupae paratypes); 4 mi NE Reynolds; Twin Falls Co: 8 mi N Roseworth, 4800 ft; 5 mi E Twin Falls, 3746 ft (2 males, 3 females, and 2 pupal exuvia paratypes).

Rhopalomyia rugosa Gagné, new species

Diagnosis

The male of this species is unknown, but the female can be separated from other tiny *Rhopalomyia* species with 1-segmented palpi and simple claws by the presence of the trichoid sensillum at the base of sternum VII and by the pupal antennal horn which has a well-developed basal spur.

Description

Male. Unknown.

Female. Wing length, 1.4-1.5 mm. Eye almost contiguous at vertex, less than 1/2 eye facet diameter apart. Antenna with 11-12 flagellomeres; neck flagellomere III 0.08 as long as node; necks indistinct beyond flagellomere IV. Fused labellum elliptic triangular, without setae. Palpus 1-segmented, elongate ovoid, without setae. Frontoclypeus with 3-4 setae per side. Anepisternum with 4-5 setae. Claws simple, empodia slightly shorter than claws. Abdomen: tergum III with 4-7 setae, V with 7-8, and VII with 8, the 2 caudal groups separated mesally; pleura without setae or scales; sterna II-VI usually each with 1 basal trichoid sensillum, 2 sometimes present, sternum VII with 1 basal trichoid sensillum, 14 setae in caudal group, and 8 in basal group, the latter separated into 2 lateral groups; tergum VII approximately 0.35 length ovipositor.

Pupa Antennal horn with single apical point and conspicuous basal spur. Frontal projection present.

Holotype, female, 23 mi S Hansen, Twin Falls Co, Idaho V-9-1968, *Artemisia tridentata vaseyana*, R. G. Jones, USNM Type No. 66627.

Biology

Seasonal occurence. Two adults emerged within 2 weeks after galls were collected May 9, 1989 at Site 6.

Gall

Description. This monthalamous gall develops from the upper surface of a persistent leaf. The coloration and pubescence of the gall surface is similar to that of the unaffected leaf. At maturity it is prune-shaped. Internally, a central cavity is lined with sclerenchyma. Only two galls, both occurring on the same leaf, were found during this study. They were 4 mm in height and 2 and 3 mm respectively in diameter.

Host plants and distribution of specimens studied

Artemisia tridentata vaseyana: IDAHO: Twin Falls Co: 22 mi S Hansen, 5700 ft (holotype female, and female and pupal exuvia paratypes).

Rhopalomyia hirtibulla Gagné, new species
(Figs. 12, 78, 79)

Diagnosis

This is the only species of those forming small leaf bump or capsule galls on big sagebrush that has toothed claws. The pupa of R. hirtibulla has bifid antennal horns, and the frontal projections are either tiny or absent. Rhopalomyia clinata Gagné, which forms a small, different kind of leaf gall on Artemisia californica in California also has toothed claws, but its pupa is quite different because of single-pointed antennal horns and large frontal projections.

Description

Male. Wing length, 1.7-2.0 mm. Eyes separated at vertex by diameter of 1 eye facet. Antenna with 12-13 flagellomeres; neck flagellomere III, 0.60-0.70 length node; neck V, 0.67-0.80 length node; neck VII, 0.75-0.82 length node. Fused labella elliptic-ovoid in frontal view, naked. Palpus 1-segmented, ovoid to elongate-ovoid, with 0-1 setae. Frontoclypeus with 0-2 setae per side. Anepisternum with 1-4 setae. Claws strong with strong tooth, the tooth occasionally bifid. Empodia as long as claws. Abdomen: tergum III with 2-5 setae per side, tergum V with 4-6, VII with 6-8, and VIII with 4-7 the groups not contiguous mesally; pleura without scales, pleuron VIII with 0-3 setae; sterna II-VII each usually with basal pair of trichoid sensilla, though occasionally reduced to 0-1 on one or more sterna, sternum VII with 10-12 setae in caudal group, 12-15 in basal, these more or less continuous across sternum. Genitalia (Figs. 78-79): basimere short, stout, in profile narrowing gradually from wide base to slightly narrower apex; telomere short, ovoid, tooth fairly narrow; sternum X slightly concave apically.

Female. Wing length, 1.2-1.4 mm. Antenna with 10-13 flagellomeres; neck flagellomere III, 0.04-0.10 length node; neck V, 0.00-0.07 length node; necks indistinct beyond IV-VII. Other head and thoracic characters as in male. Abdomen: tergum III with 2-5 setae per side, V with 3-4, and VII with 5-6; pleura without scales or setae; sterna II-VII usually with basal pair of trichoid sensilla, sternum VII with 9-14 distal setae, 4-7 basal, this group divided mesally; tergum VII 0.28-0.31 length distal half of ovipositor.

Pupa. Antennal horn strongly developed, bifid apically, the inner projection subequal in length to or slightly shorter than outer projection. Anterior portion of frons imediately basad of antennal horn in lateral view raised above general surface of rest of frons; frons with or without short pair of lateral projections.

Holotype, male, 3 mi N Mt. Home, Elmore Co., Idaho, III-24-1969, Artemisia tridentata, R. G. Jones, USNM Type No. 66628.

Biology

Seasonal occurrence. Immature larvae were found at Site 15 on July 19, 1968 coinciding with the first sign of galls. Larvae were found throughout the rest of the year with mature larvae present the following spring. Adult emergence occurred on March 29, 1969 from galls collected March 24 at Site 15. In 1970, emergence occurred from March 27-29 from galls collected March 23.

Gall

Description and development. This small monothalamous gall (Fig. 12) occurs singly or in small to large confluent groups. The galls are densely clothed with long trichomes giving them a white fuzzy appearance. The mature gall is approximately 1 mm in diameter and of equal height. Emergence of the adult from a central larval chamber results in a small circular hole (Fig. 23) at the top of the gall.

Developing galls were first observed on July 19, 1968 at Site 15. They are similar in appearance to the mature galls. Growth was completed between that date and the end of March of the following year. Old galls remain on the plant until the persistent leaf series is shed.

Effect on the plant. These galls were always found concentrated on a small plant or on a single branch of a large plant. Such concentrations of galls gives the plants, especially those of small size an overall unthrifty appearance.

Associated insects

Platygasteridae. Platygaster sp. emerged from galls collected at Site 18 and was determined to be a parasitoid of this midge species. Another species of Platygaster, also a parsitoid, emerged from galls collected at Site 15.

Chalcidoidea. Tetrastichus sp. and a species of Pteromalinae and Encyrtidae were reared from galls, but their specific association of R. hirtibulla was not established.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft; Clark Co: 3.5 mi W Dubois, 5150 ft; Custer Co: 5 mi E Clayton, 5650 ft; UTAH: Salt Lake City (9 females).

A. tridentata tridentata: IDAHO: Butte Co: 7 mi E Howe (pupa, paratype); Cassia Co: City of Rocks (5 males, 3 females and 5 pupae, paratypes); 4 mi E Idahome, 4400 ft; Lemhi Co: 16 mi N Salmon, 4000 ft; MONTANA: Beaverhead Co: 17 mi E Bannock Pass Summit.

A. tridentata vaseyana: IDAHO: Franklin Co: 3 mi W Dayton, 4800 ft; Twin Falls Co: 22 mi S. Hansen, 5700 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (holotype, male, and 19 males, 11 pupae, paratypes); Owyhee Co: 3 mi SW Walter's Ferry.

Rhopalomyia brevibulla Gagné, new species
(Figs. 13, 76, 77)

Diagnosis

This species forms galls similar to those of R. hirtibulla except that they are not covered by long trichomes. Adults of R. brevibulla have the tarsal claws simple rather than toothed and quite distinctive male genitalia. The pupae of these two species are similar.

Description

Male. Wing length, 1.5-1.7 mm. Eyes separated at vertex by slightly more than the diameter of 1 eye facet. Antenna with 11-12 flagellomeres; neck flagellomere III, 0.55-0.63 length node; neck V, 0.63-0.70 length node; and neck VII, 0.55-0.60 length node. Fused labella hemispherical in frontal view, naked. Palpus 1-segmented, ovoid, with 0-1 setae. Frontoclypeus with 2-4 setae per side. Anepisternum without setae. Claws simple, strongly curved. Empodia as long as claws. Abdomen: tergum III with 1-2 setae per side, V with 2-3, VII with 2-4, and VIII with 0-3, the groups divided mesally; pleura naked; sterna without trichoid sensilla, sternum VII with 7-10 setae in caudal group, 7-14 in basal, these evenly distributed across sternum. Genitalia (Figs. 76-77): basimere only slightly larger basally than apically, unlobed; telomere elongate-ovoid, the tooth narrow, longer than wide, slightly recumbent; sternum X quadrate.

Female. Wing length, 1.4-1.5 mm. Antenna with 11-12 flagellomeres; neck flagellomere III, 0.10-0.11 length node; neck V, 0.10-0.12 length node; necks absent beyond V or VI. Other head and thoracic characters as in male. Abdomen: tergum III with 0-1 setae per side, V with 2-3, and VII with 3-4; pleura naked; sterna without trichoid sensilla, sternum VII with 8-10 setae caudally, 5-7 basally; tergum VII ca. 0.40 length distal half of ovipositor.

Pupa. Antennal horn weakly bifid, the inner projection shorter than outer. Anterior portion of frons immediately basad of antennal horns in lateral view raised above general surface of rest of frons; frons with weak pair of lateral projections.

Holotype, male, 3 mi N Mt. Home, Elmore Co, Idaho, III-18-1970, *Artemisia tridentata wyomingensis*, R. G. Jones, USNM Type No. 66629

Biology

Seasonal occurrence. Numerous females were observed ovipositing at 55°F on *A. t. wyomingensis* at 1100 hours on March 23, 1970 at Site 15. Their red eggs were readily found at the base of leaves, in crevices on overwintering branch tips and on twigs. Galls were collected at this time for laboratory rearing. Adults emerged over the following two days.

Gall

Description. This small monothalamous gall (Fig. 13) is similar in size and structure to that of *R. hirtibulla*. The grayish surface of the mature gall is clothed with trichomes the same as on the leaf. The galls occur singly or in large clusters both on the persistent leaf series and stems of the previous year's growth. Adult emergence holes are similar to those of *R. hirtibulla* (Fig. 12). The galls have been found on only one small plant at the type locality.

Host plants and distribution of specimens studied

Artemisia tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (2 males, 3 females, 3 pupal exuvia, paratypes).

Rhopalomyia tumidibulla Gagné, new species
(Figs. 15, 51, 52, 80, 81)

Diagnosis

Rhopalomyia tumidibulla belongs to a large artificial group of species with 1-segmented palpi and simple claws, but the male has a distinctive, strongly attenuate telomere and the ovipositor is fairly short. The pupal antennal horns are unique in that they are strongly bifid and have a ventrobasal spur.

Description

Male. Wing length, 2.5-2.6 mm. Eyes separated at vertex by about 1 facet diameter. Antenna with 13 flagellomeres; neck flagellomere III, 0.53-0.62 length node; neck V, 0.59-0.73 length node; neck VII, 0.62-0.76 length node. Fused labella small, ellipsoid, each labellum with 0 or 1 setae. Palpus 1-segmented, long-ovoid, tapering to apex, bearing 0 or 1 setae. Claws simple, strongly curved and well developed. Empodium slightly shorter than claws. Abdomen: tergum III with 9-11 setae per side, tergum V with 7-21, tergum VII with 9-13, and tergum VIII with 4-9, the caudal groups of setae not contiguous mesally; pleura without scales, pleuron VIII with 4-6 setae; sterna II-VII each with a basal pair of trichoid sensilla; sternum VII with 20-24 setae in distal group, 20-24 in basal group, these continuous across width of sternum. Genitalia (Figs. 80-81): basimere short, stout, in lateral view tapering gradually from wide base to apex; telomere long, strongly attenuate from base to narrow apical tooth; sternum X truncate apically.

Female. Wing length, 1.9 mm. Antenna with 12 flagellomeres; neck flagellomere III, 0.09 length node, necks indistinct beyond flagellomere II or IV. Other head and thoracic characters as in male. Abdomen: tergum III with 11 setae per side, tergum V with 14-16, and tergum VII with 8-9, the 2 caudal groups not contiguous mesally; pleura without scales, pleuron VII with 3 setae; sterna II-VII each with 2 basal trichoid sensilla, sternum VII with 19-23 setae in caudal group, 7-8 in basal group which is separated mesally; tergum VII approximately 0.39 length distal half of ovipositor.

Pupa (Figs. 51-52). Antennal horn with bifid apical projection and strong basal spur. Frons with pair of angular, bilaterally compressed projections.

Holotype, male pupa (with enclosed, fully developed male), 3 mi N Mt. Home, Elmore Co., Idaho, III-18-1970, Artemisia tridentata wyomingensis, R. G. Jones, USNM Type No. 66630.

Biology

Seasonal occurence. Adults emerged in the laboratory on March 25-26 from galls that had been collected March 18, 1970. In the previous year's rearing, they emerged on April 24-25 from galls collected April 22, 1969. Adult emergence was not observed in the field.

Gall

Description. This monothalamous gall, when mature, consists of a swelling that is apparent on both surfaces of a persistent leaf (Fig. 15). A sclerenchymatous larval capsule is located centrally within the leaf swelling. Two mature galls measured 3 mm in depth, 3 mm across the leaf widthand 4 mm along the leaf length.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft (male, female, paratypes).

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (holotye male and 2 males, pupa, and pupal exuvium, paratypes).

A. tridentata vaseyana: IDAHO: Twin Falls Co: Magic Mt. Ski Area (2 females and pupa, paratypes).

Rhopalomyia spp.

Several minute, capsular, monothalamous leaf galls other than those of the last three named species were found in this study. They are not named here because adults either were not reared from them, or two or more apparent midge species were taken from the same type of gall. The few pupae and males taken from these galls are distinct from those of the preceding leafgall formers. The gall types were as follows:

1. An elongate, capsular gall with a very dense coat of short trichomes, which gives the surface a white appearance (Fig. 14). In clusters the galls superficially resemble bird droppings. They were found only once on an unthrifty of A. t. vaseyana plant growing under a juniper tree 4 mi W of Almo, Cassia Co., Idaho.
2. A gall about 1.0 mm long, 0.5 mm wide, with a thin, translucent yellow-brown outer wall. This gall was found in April on the leaves of A. t. vaseyana at the following Idaho localities: Blaine Co: 6 mi S Ketchum, 5500 ft (specimens reared); Camas Co: 12 mi S Fairfield, 5450 ft (specimens reared); Custer Co: 8 mi NW Mackay, 6200 ft (specimens reared); Twin Falls Co: 22 mi S Hansen, 5700 ft (specimen reared).
3. A similar appearing early spring gall found on one occasion on the bud axils of new growing branch tips of A. t. wyomingensis, 7 mi S. Mt. Home, Elmore Co., Idaho and on two occasions in the center of open buds of A. tridentata, 11.5 mi W Kimama, Lincoln Co., Idaho and 6 mi E. Bannock Pass Summit, Beaverhead Co., Montana. Only females were reared from these galls.
4. A gall similar in form, size, and structure to the preceding, but differing in that the translucent wall is sparsely covered with long trichomes. It was found 17 mi E of Bannock Pass Summit, Beaverhead Co., Montana.
5. A slightly larger leaf gall than the three preceding, and with an internal sclerenchymatous larval capsule about 1.0 mm in length and 0.5 mm in diameter. It was found at several localities in Idaho on Artemisia tridentata: 4 mi W Almo, 6200 ft., Cassia Co. (specimens reared; 3.5 mi W Dubois, 5150 ft, Clark Co; 3 mi W Dayton, 4800 ft, Franklin Co. and 2 mi E Acequia, 4200 ft, Minidoka Co (specimens reared).

Rhopalomyia ampullaria Felt
(Figs. 16, 17, 53, 54, 82, 83)

Rhopalomyia ampullaria Felt 1916e:185.

Diagnosis

Rhopalomyia ampullaria is a small species with simple claws, 1-segmented palpi, lacking trichoid sensilla on the abdominal sterna, and otherwise sparsely setose. It is easily separated from its most similar congeners by the long, unlobed male basimere, narrow-toothed, ovoid telomere, and the weakly developed claws.

Description

Male. Wing length, 1.7-1.8 mm. Eyes almost contiguous at vertex, less than 1 facet diameter apart. Antenna with 10-12 flagellomeres; neck flagellomere III, 0.52-0.62 length node, neck V, 0.52-0.75 length node, neck III, 0.64-0.71 length node. Fused labella ellipsoid in frontal view, with 0-1 setae per labellum. Palpus 1-segmented, elongate-ovoid, with 0-3 setae. Frontoclypeus with 1-6 saetae per side. Anepisternum with 2-5 setae. Claws simple, strongly curved. Empodium approximately as long as claws. Abdominal tergum III with 3-4 setae; V with 3-7; VII with 4-6; and VIII with 3-4; lateral groups of setae not contiguous mesally. Pleura without setae but with scattered sclaes. Sterna II-VIII without trichoid sensilla; sternum VII with 12-15 setae in distal group, 11-14 in basal group, this either broken mesally or continuous across sternum. Genitalia (Figs. 82-83): basimere tapering gradually from base to apex, not very setose, not lobed; telomere short, ovoid, tooth narrow, approximately as wide as long; sternum X truncate, the leading edge slightly concave.

Female. Wing length, 1.3-1.6 mm. Antenna with 10-13 flagellomeres; necks on basal flagellomeres either indistinct or less than 0.10 length node. Other head and thoracic characters as in male. Abdominal tergum III wioth 2-19 setae; V with 4-20; and VII with 3-13; lateral groups of tergal setae not contiguous mesally. Pleura without setae; distal segments with a few scattered scales. Sterna without trichoid sensilla; sternum VII with 6-14 setae in distal group, 6-18 in basal, these separated mesally into two groups. Tergum VII 0.26-0.30 length distal half of ovipositor.

Pupa (Figs. 53-54). Antennal horn not greatly produced. Spurs present ventrobasally. Frons with pair of acute, angular, bilaterally compressed projections.

Lectotype: here designated, female, reared VII-6-1913, near Salt Lake City, Utah, Artemisia tridentata, P. H. Timberlake, C1618, in Felt Collection. Paralectotype: pupal exuvia, same data as lectotype.

Biology

Seasonal occurrence. This species has two generations per year. The summer generation develops in galls principally on ephemeral leaves while the overwintering generation develops in galls on flower buds.

The eggs of the summer generation were not found. The bright red eggs of the overwintering generation were present singly or in small clusters of two-five on the surface of young flower heads, usually protected by the subtending bract, stem or by another flower head. An average of three eggs per cluster occurred at 36 oviposition sites.

Immature larvae of the summer generation were found on *A. t. tridentata* at Site 1 on May 14, 1969 when the ephemeral leaf galls were first evident. Mature larvae were found on July 24, 1969 at Site 13. Immature larvae of the overwintering generation were present at Site 13 on September 23, 1969 when galls in the flower bud were first apparent. This generation reached larval maturity by March 19, 1970.

Pupal exuvia were found protruding from leaf galls at Site 13 on July 20, 1969. Midge emergence at this site was then followed through August 5. In 1968 emergence had occurred at the same site sometime between July 26 and August 13. On both July 20, 1969 and July 26, 1968 the ephemeral leaves of the sagebrush plants were found to be drying and *Chrysothamnus viscidiflorus* (Hook), an associated shrub species, was in early bloom while the flower buds of *C. nauseosus* (Pall.), another associated shrub species, were turning yellow. Field emergence of the overwintering generation was not followed.

Under laboratory conditions, adult emergence from ephemeral leaf galls collected July 16, 1969 at Site 13 occurred from July 23 through 28. Emergence began on July 30 and continued through August 5 from galls with pupae collected on July 23-28. Adult emergence from galls in flower buds collected at the same site March 19, 1970 occurred from March 27 through 31.

Ninety leaves placed in individual rearing containers had an average of 4.08 galls with a range from 1-22 galls per leaf. Midge or parasitoid emergence occurred from 107 galls on 44 leaves. Examination of 174 galls on 36 leaves after midge emergence showed the contents of 19 unaccounted for and 83.9% of the midges in the remaining gall had been parasitized.

Three virgin adult females of the summer generation contained from 142-172 eggs (avg. 160.7) and 1 mature female pupa contained 171 eggs.

Emergence. Female emergence on August 1, 1969 at Site 13 began at sunrise or shortly after 0600 at a temperature of approximately 50°F. The emergence of one individual was complete in 24 minutes from the time the pupa broke through the pointed apex of an ephemeral leaf gall. This activity was similar to that described for *R. pomum* with the pupal exuvia remaining attached to the gall. No male emergence was observed.

Male flight. Flight activity of newly emerged males as indicated by trapping (Table 6) began at about sunrise in temperatures above 50°F. Up to 134 males were caught on a single trap board surface. Flight activity lasted for approximately 2 hours.

Oviposition. Four ovipositing females were observed at 0850 on August 1 and another at 1045. From the limited observations made, oviposition of *R. ampullaria* appears similar to that of *R. pomum* and differs only in the specific ovipositional site and in the number of eggs deposited.

Description and development. The monothalamous gall caused by the summer generation of this midge occurs singly or in confluent groups, predominantly on the ephemeral leaves (Fig. 16) and only occasionally on flower bracts and stems (Fig. 17). The mature gall is woody and consists of a rounded base on one surface of a leaf and a conical portion on the opposite surface. The gall surface has the same color and dense covering of trichomes as a normal leaf. A larval chamber is centrally located in the base and is separated by a thin septum from the conical portion which is hollow. The apex of the conical portion is membranous. The conical portion of 67 mature galls ranged from 2-7 mm (avg. 4.18) in height and 1-3 mm in width at the leaf surfaces.

Gall

The flower bud gall of the overwintering generation is not readily visible. The affected buds remain closed during bloom and the gall can be found only by forcing open the involucral bracts. An elongate

Table 6. Numbers of Rhopalomyia ampullaria adults entrapped hourly in relation to temperature and relative humidity for three days at Site 13, Cassia Co., Idaho, 1969.

Date	Recording	0600	0700	0800	0900	1000	1100	1200
29 July	Males	--	223	25	3	0	0	0
	Females	--	0	3	4	3	0	0
	Temperature (^{O}F)	62	60	66	70	77	81	81
	Relative Humidity (%)	64	78	71	59	52	41	50
1 August	Males	--	31	33	1	0	0	--
	Females	--	0	0	1	0	0	--
	Temperature (^{O}F)	50	52	67	73	77	79	--
	Relative Humidity (%)	49	57	41	35	26	25	--
5 August	Males	--	3	11	3	0	0	--
	Females	--	0	0	0	1	0	--
	Temperature (^{O}F)	54	54	56	58	63	67	--
	Relative Humidty (%)	48	37	34	32	33	30	--

sclerenchymatous larval capsule with a dense covering of long white trichomes replaces the flower. During the period of full bloom the capsule is green but after bloom the gall becomes translucent and colored much like that of the dry involucral bracts. By the summer following adult emergence, all galls have dropped from the plant. The few mature galls measured were approximately 2 mm in length and 1 mm in width.

Developing galls on ephemeral leaves were first observed on May 14, 1969 at Site 1 on A. t. tridentata. At this time new stem growth was about 7.5 cm in length. Galls had attained maximum size by July 24 coinciding with the presence of pupae. At that time the old persistent leaves, if present, were dry, new persistent leaves were well-developed and distinctly tridentate, the ephemeral leaves were mature and the flower heads of Chrysothamnus viscidiflorus were yellow but not open. The galls persist on the plants for only a short time after adult emergence. By the first of September during early bloom the ephemeral leaves become dry and are shed.

Effect on the plant. Although most ephemeral leaves on many plants at Site 13 had one to many galls, the plants appeared thrifty. The development of galls in the flower buds prevent flower and seed formation.

Associated insects

Chalcidoidea. Several parasitoid species were reared from the galls, including Torymus koebelei (Huber), Tetrastichus sp., a species of Pteromalinae and a species of Encyrtidae.

Host plants and distribution of specimens studied

A. tridentata: UTAH: Salt Lake City (Type-series ampullaria).

Artemisia tridentata tridentata: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft (specimens reared); Lincoln Co: 11.5 mi W Kimama, 4275 ft; Twin Falls Co: 11 mi S Hansen, 4300 ft; 5 mi E Twin Falls, 3746 ft; 23 mi SW Twin Falls, 4950 ft.

A. tridentata vaseyana: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft (specimens reared); 8 mi W Almo, 6300 ft; 8 mi W Elba, 6350 ft; Twin Falls Co: 21 mi S Hansen, 5240 ft; 17 mi S Hansen, 4725 ft; 22 mi S Hansen, 5700 ft

A. tridentata wyomingensis: IDAHO: Cassia Co: 4 mi W Almo 6200 ft.

Rhopalomyia culmata Gagné, new species

(Fig. 18)

Diagnosis

This medium-sized species shows a resemblance to R. cramboides and other bud gallmakers on the basis of toothed claws, one-segmented palpus, and shape of the pupal head. However, the male genitalia are similar to those of R. obovata and R. nucula.

Description

Male. Wing length, 2.4-2.6 mm. Eyes separated at vertex by less than 1 facet diameter. Antenna with 14 flagellomeres. Fused labella short-ellipsoid, 0-2 setae per side. Palpus 1-segmented with 0-2 setae.

Frontoclypeus with 4-10 setae per side. Anepisternum with 3-4 setae. Claws toothed. Empodia slightly shorter than claws. Abdomen: tergum III with 12-13 setae per side, V with 12-14, VII with 11-13, and VIII with 10-14 setae, the setal groups not contiguous mesally; pleura I-II with many scales, III-VII naked, VIII with 5-8 setae, sterna II-VII with basal pair of trichoid sensilla, sternum VII with 18 setae in caudal group, 21 in basal, these continuous across sternum. Genitalia: basimere short with large basoventral lobe; telomere widest at about midlength, truncate apically, the tooth short, narrow; sternum X truncate.

Female. Wing length, 2.0 mm. Antenna with 13 flagellomeres, their necks indistinct beyond VIII-IX. Other head and thoracic characters as in male. Abdomen: tergum III with 9-16 setae per side, V with 13-16, and VII with 8-11; pleura I-II with many scales, other pleura naked; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 16-17 setae in caudal group, 16-18 in basal, these continuous across sclerite; tergum VII approximately 0.40 length distal half of ovipositor.

Pupa. Antennal horns short, the posteroventral corner weakly produced. Frons with short ridge immediately caudad of each antennal horn and with pair of triangular projections lateral of clypeal base.

Holotype, male, 3 mi N Mt. Home, Elmore Co., Idaho, IV-18-1972, *Artemisia tridentata wyomingensis*, Barr, Gagné and Gillespie, USNM Type No. 66631.

Biology

Seasonal occurrence. Pupal exuvia were found on a gall on May 27, 1969 at Site 3. Adults were reared April 21-26, 1972 from galls collected April 18 at Site 15.

Gall

Description and development. This monothalamous gall appears to be associated with one of the first ephemeral leaves that develop in the bud. The mature gall consists of a long, thin erect stalk with an enlarged apex made up of the fused lobes of the leaf tip (Fig. 18) surrounding a sclerenchymatous larval capsule. Some galls have a whorl of spatulate leaves at the base of the stalk. Two galls that were measured had stalks 10 mm long and the enlarged apical portions 5 mm long by 2 mm wide.

Host plants and distribution of specimens studied

Artemisia tridentata tridentata: IDAHO: Twin Falls Co: 23 mi SW Twin Falls, 4950 ft (pupal exuvia).

A. tridentata vaseyana "f. *xericensis*": IDAHO: Washington Co: 8 mi N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (holotype, male, and male, 3 females, and 5 pupal exuvia, paratypes).

Rhopalomyia gossypina Gagné, new species

(Figs. 19, 20, 84, 85)

Diagnosis

This species has a 1-segmented palpus and toothed claws as do most sagebrush midges. The pupa has short antennal horns and frontal projections similar to many of the other bud gall makers, but the large basal lobe of the male basimere sets R. gossypina apart. The pointed palpus with its many setae arranged around the apex is also distinctive for the adult.

Description

Male. Wing length, 2.4-2.7 mm. Eyes contiguous at vertex. Antenna with 16-17 flagellomeres; neck flagellomere III, 0.67-0.72 length node; neck V, 0.76-0.80 length node; neck VII, 0.73-0.77 length node. Fused labella hemispherical in frontal view, usually with apical indentation; each labellum with 5-10 setae. Palpus 1-segmented, elongate-ovoid, usually tapering abruptly to pointed apex, with 5-13 setae near apex. Frontoclypeus with 5-7 setae per side. Anepisternum with 8-13 setae. Claws strong, toothed, the teeth small and narrow. Empodia as long as claws. Abdomen: tergum III with 15-21 setae per side, V with 22-26, VII with 20-28, and VIII with 16-31, scales interspersed with setae on terga VII and VIII and a few on disk of VIII; pleura II-V with 0-1 seta, VI with 304 setae, VII with 5-0, and VIII with 9-15, scales numerous on pleura VI-VII, occasional on others; sterna II-Vii each with basal pair of trichoid sensilla, sternum VII with 21-27 setae in distal group and 31-39 in basal, the latter group continuous across the sternum. Genitalia (Figs. 84-85): basimere in lateral view with very large basal lobe; telomere elongate-ovoid, tooth wide; sternum X margin truncate to slightly concave.

Female. Wing length, 1.8-2.0 mm. Antenna with 15-16 flagellomeres, necks indistinct. Other head and thoracic characters as in male. Abdomen: tergum III with 15-21 setae per side, V with 15-22, and VII with 16-20, the two groups on tergum VII contiguous mesally or nearly so; pleura I-V naked, VI with 0-1 setae, VII with 2-4, and VIII with 7-8, the two last segments with a few scales; sterna II-VII each with basal pair of trichoid sensilla, ssternum VII with 27-34 setae in distal group and 11-14 in basal group which is divided mesally; tergum VII 0.35-0.38 length distal half of ovipositor.

Pupa. Antennal horn short, the apex projecting ventrally. Frontal projections short.

Holotype, male, 2 mi E Acequia, Minidoka Co., Idaho, IX-11-1969, Artemisia

Biology

Seasonal occurrence. In the field, adults began emergence prior to September 15, 1969 at Site 24. Emergence was still in progress on September 23. Adults were reared for two consecutive years from galls collected at Site 24. Emergence from galls collected September 6, 1969 occurred from September 10-16, but no emergence took place from an August 26 collection of galls. Emergence from galls collected September 11, 1969 occurred from September 13-20.

Individual rearing of 50 galls from the 1969 collection indicates a similar emergence phenomenon to that of R. pomum. Only male midges emerged from 12 galls and only females from another 12 galls. Both males and females emerged from only 3 galls. Because many galls did not have an adults emerge, all 50 galls were subsequently dissected. The galls each contained from 1-19 sclerenchymatous larval capsules (avg. 4.4). The contents of 216 of the capsules were accounted for with midges having emerged from 34.3% and parasitoids in or emerged from 65.7%.

A large number of galls with emerging midges was placed in three cages each containing a potted A. t. tridentata plant. These plants were transferred to a greenhouse in late October 1969. On January 20, 1970 four galls were found developing on one of the plants. These galls were typical of those found in the field.

Emergence. Daily activity begins with emergence of the adult from the gall. Emergence is similar to that of *R. pomum* differing only in that the pupae wiggle through the long trichomes after breaking from the capsule. The pupal exuvia remain attached to these trichomes (Fig. 19).

At Site 24 female emergence began about two hours after sunrise at 40°F on September 15. No males emerged. Females began emerging at sunrise on September 18, 1969 at approximately 50°F while earlier males were observed clinging to foliage.

Male flight. Each morning, a flight of newly emerged males coincided with female emergence (Table 7). The males flew about the gallbearing branches in search of females, mating, and then flying on. This activity was similar to that of *R. pomum*. Males occurred singly or in mating groups of 2-4. While most activity was completed within two hours, a few males were observed in flight more than three hours after these activities had begun. One male began flight at 45°F but all other observed flight was at 50°F or above. The wind was generally calm during the study period.

Mating. Females were ready to mate after their wings expanded. Females mated once, whereas males were observed to mate with more than one female. The copulatory position was similar to that of *R. pomum* with 12 pairs copulating for periods ranging from 11 to 25 seconds (avg. 17.9). After copulation the females retracted their ovipositors and then rested on the foliage.

Oviposition. Oviposition activites begin with the female crawling to the buds and ovipositing quite like the female of *R. pomum*. With the first egg mass deposited, the female flies to a nearby branch or another plant. On September 18 at Site 24, three females that had emerged about 0730 and mated about 0820, began ovipositing about 1000. Few females were observed by 1200 each day, and none was seen by 1300. The bright red eggs of this species were found on one occasion in masses between the bases of two persistent leaves on the outside surface of developing leaves in the bud. Ten egg masses contained from two to 65 eggs, with an average of 42 per mass. Three virgin adult females contained 115-250 eggs (avg. 187) and one mature female pupa contained 208 eggs.

Gall

Description and development. This gall is a composite growth of the branch tips and buds (Fig. 19). At maturity it consists of 2-4 short, malformed, developing stems that are grouped in a globose mass of white trichomes from which green leaves protrude. The surface of these stems is densely clothed with white trichomes which are longer than the linear leaves arising from these stems. Hidden by the dense trichome mass, sclerenchymatous larval capsules are on the axis of the stems. These capsules are elongate cylinders with a rounded apex and a thin hard wall. The galls are generally found concentrated on one branch.

Fifty mature galls ranged in height from 8-15 mm (avg. 11.68). Their width ranged from 8-16 mm (avg. 12.88). Five of the larval capsules were approximately 2 mm in height and 1 mm in width.

Early development of this gall was noted on June 5, 1969 at Site 24. The immature gall is recognized as a mass of white trichomes subtended by a whorl of developing ephemeral leaves at the tip of a developing stem. At this time the normal stems were up to 20 cm in length, the flower branches were not yet distinctive, and the persistent leaves were just out of the bud. The galls increase in size during the summer and reach what appears to be maximum size in late August when the ephemeral leaves begin to dry. The galls remained

Table 7. Numbers of *Rhopalomyia gossypina* adults entrapped hourly in relation to temperature and relative humidity for three days at Site 24, Minidoka Co., Idaho, 1969.

Date	Recording	0700	0800	0900	1000	1100	1200	1300
15 September	Males	--	0	1	7	2	1	0
	Females	--	0	0	1	1	1	1
	Temperrature (°F)	33	34	45	53	61	63	68
	Relative Humidity (%)	80	81	51	52	31	29	27
17 September	Males	--	0	18	6	0	0	0
	Females	--	0	0	0	2	3	2
	Temperature (°F)	46	45	61	65	73	76	76
	Relative Humidity (%)	86	68	54	52	35	34	38
18 September	Males	--	27	25	0	0	0	0
	Females	--	0	0	0	1	2	0
	Temperature (°F)	49	52	65	74	78	78	83
	Relative Humidity (%)	73	69	48	36	30	33	28

unchanged in appearance after adult emergence and throughout the winter. The following spring the trichomes on the gall surface become drab. The old galls persist up to two years and perhaps longer in sheltered parts of the plant.

Effect on the plant. All the seasonal growth from a branch tip is utilized in gall formation with exception of the first ephemeral leaves. When galls are present in large concentrations on the plant, branch or even plant mortality occurs.

Most of the branches of one plant observed during the summer of 1968 carried old or developing galls. The following season the few remaining healthy branches had developing galls and all the other branches were devoid of foliage (Fig. 20).

Associated insects

Curculionidae. One specimen of Apion sordidum emerged on September 29 from one of the 50 galls placed in rearing on September 11, 1969.

Tephritidae. Oxyna palpalis (Coquillett) was reared from galls collected at three of the four sites where R. gossypina occurred. The exception was Site 3. The larvae burrow in the basal region of the gall. No apparent damage occurred to the midge chambers, but most feeding takes place after midge emergence.

Platygasteridae. Platygaster sp. was found to parasitize the midge. This species emerged in rearing concurrent with midge emergence and for about a week after.

Chalcidoidea. Several species including Torymus aeneoscapus were reared from the galls. Some are known to have parasitized R. gossypina but associations of the others are unknown.

Host plants and distribution of specimens studied

Artemisia tridentata tridentata: IDAHO: Butte Co: 7 mi E Howe; Cassia Co: 2.5 mi SE Basin, 4200 ft; Lincoln Co: 10.5 mi NE Richfield, 4700 ft; Minidoka Co: 2 mi E Acequia, 4200 ft (holotype and 26 males, 19 females, and 3 pupal exuvia, paratypes); Twin Falls Co: 23 mi SW Twin Falls, 4950 ft.

Artemisia tridentata vaseyana: IDAHO: Blaine Co: Big Wood River, 10 mi SE Bellevue.

Rhopalomyia lignea Gagné, new species

(Figs. 21, 55, 56)

Diagnosis

The pupal antennal horns of R. lignea are the longest of all the A. tridentata gall midges but are similar to those of R. betheliana Cockerell, a species reared from A. frigida in Colorado. These two species are similar in other respects also in the lack of projections on the pupal frons and the sparse setae, 1-segmented palpi, and number of flagellomeres of the adults. They are readily separated by the relative length of the pupal pronotal setae which are much shorter in R. lignea and by the fact that the claws are toothed in R. lignea, simple in R. betheliana.

Description

Male. (only teneral specimens available). Antenna with 15 flafellomeres. Fused labella with one pair of setae. Palpus 1-segmented, elongate-ovoid, setose. Frontoclypeus with three setae per side. Claws each with small tooth. Empodia approximately as long as claws. Abdomen: tergum III with 18 setae, V with 17, VII with 14, and VIII with ______; pleura naked; sterna II-VII each with two basal trichoid sensilla. Genitalia: basimere wide at base, tapering gradually to narrower apex; telomere ovoid, the tooth wide; sternum X truncate apically.

Female. Eyes almost contiguous at vertex. Antenna with 14 flagellomeres; neck flagellomere III, 0.06 length node; neck V, 0.04 length node; neck indistinct beyond flagellomere V. Fused labella with two pairs of setae. Palpus as in male. Frontoclypeus with four setae per side, V with 15, and VII with 8, the lateral groups not contiguous mesally; pleura naked; sterna II-ViII each with basal pair of trichoid sensilla, sternum VII with 16 setae in distal group, 15 in basal, the latter divided mesally; tergum VII approximately 0.33 length distal half of ovipositor.

Pupa (Figs.55-56). Antennal horns very long, tapering gradually to apex. Frons smooth. Pronotal setae short.

Holotype: male pupa, 8 mi NW Mackay, Custer Co., Idaho, III-22-1968, Artemisia tridentata vaseyana, R. G. Jones, USNM Type No. 66633.

Biology

Seasonal occurrence. Adults emerged from galls in the laboratory within two weeks of their collection on April 22, 1968 at Site 14.

Gall

Description. This bud gall (Fig. 21) is a confluent mass of swollen leaf rudiments which are green and densely covered with trichomes. Each leaf rudiment tapers from a broad base to a blunt apex, becomes woody at maturity, has a single larval chamber at the base, is hollow in the center, and has a thin septum at the apex that bears a mass of long trichomes. The hollow portion is utilized by the pupa to facilitate escape. The pupal exuvium remains at the ruptured septum. The old galls persist on the plant indefinitely. Three mature galls had a respective length of 8, 6, and 8 mm with a basal width of 4, 4, and 6 mm.

Effect on the plant. The formation of these galls marked the end of any normal growth from the buds. However, these galls were never abundant enough to cause any significant damage to sagebrush plants.

Host plants and distribution of specimens studied

Artemisia tridentata tridentata: IDAHO: Twin Falls Co: 11 mi S Hansen, 4300 ft.

A. tridentata vaseyana: IDAHO: Custer Co: 1 mi NW Mackay, 6200 ft (IV-22-1968, holotype, male pupa, and 1 male pupa and 1 female, paratypes); 2 mi N Riddle, 5400 ft.; Twin Falls Co: 17 mi E Rogerson, 5700 ft.

Rhopalomyia sp. near lignea

(Fig. 22)

Diagnosis

The two females (the only available specimens) resemble those of R. lignea by their large size (2.0-2.1 mm), 1-segmented palpus, weak-toothed claws, and presence of a basal pair of trichoid sensilla on each of the abdominal sterna II-VII. Because their galls are distinct from those of R. lignea we are treating this as a separate species. We lack males and pupae to make proper comparisons, and thus it is not being named at this time.

Biology

Seasonal occurrence. Immature larvae were found at Site 23 on August 28, 1969, in newly developing galls. Adults emerged April 20 and 21, 1969 from galls collected at that site on April 19.

Gall

Description. This reddish gall (Fig. 22) with a sparse trichome covering is generally similar to that of R. lignea. It occurs singly or in a confluent mass of leaf rudiments. It is elongate with a broad base and tapering to a blunt apex, which has a prominent swelling. A larval chamber is present at the base and the center is hollow. As with R. lignea the hollow portion is utilized in emergence.

Developing galls were first found on August 28, 1969 at Site 23. The galls reached maximum size prior to the presence of pupae on April 17, 1969. With maturity the galls are woody and persist on the plant for many years after adult emergence. Three mature galls from A. t. tridentata had a length of 5 mm and a basal width of 3 mm while a fourth was 6 mm long with the same width.

Effect on the plant. All growth from the bud is utilized in gall formation; however, the galls were never abundant or concentrated so no overall detrimental effect was observed.

Host plants and distribution of specimens studied

Artemisia tridentata tridentata: IDAHO: Cassia Co: 6 mi. NE Malta, 4400 ft; Lemhi Co: 16 mi N Salmon, 4000 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft (IV-20-1969, 2 females); 10.5 mi NE Richfield, 4700 ft; Minidoka Co: 2 mi E Acequia, 4200 ft.

Rhopalomyia lignitubus Gagné, new species
(Figs. 23, 24)

Diagnosis

This species is most similar to R. gossypina in its 1-segmented palpus, toothed claws, and large-lobed basimere; however, the palpal setae are not clustered near the apex of the palpus and the tarsal claws are more strongly developed in R. lignitubus than they are in R. gossypina. Both species have pupae that are similar to most of the other large bud gallmakers.

Description

Male. Wing length, 3.1 mm. Eyes less than 1 facet diameter apart at vertex. Antenna with 17 flagellomeres; neck flagellomere III, 0.50 length node; neck V, 0.53 length node; neck VII, 0.55 length node. Fused labella hemispherical in frontal view with apical indentation, 1-3 setae per labellum. Palpus 1-segmented, elongate-ovoid to fusiform, with 2-5 setae. Anepimeron with 11-13 setae. Claws toothed, teeth strong; empodia as long as claws. Abdomen: tergum III with 18-19 setae per side, V with 24-28, VII with 17-24, and VIII with 15-25; pleura I-V naked, VI-VIII with 1-6 setae, and VIII with 11-14 setae and several scales; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 30-48 setae in distal group, 36-45 in basal. Genitalia: basimere short with large mesoventral lobe; telomere ovoid with wide tooth; sternum X truncate apically.

Female. Wing length 1.9 mm. Antenna with 13-15 flagellomeres; necks flagellomeres III, V, VII, 0.05-0.10 length respective nodes; necks indistinct beyond VII-VIII. Anepimeral setae, 3-4. Other head and thoracic characters as in male. Abdomen: tergum III with 12-14 setae per side, V with 12-19, and VII with 17-25; pleura I-V naked, VI-VII with 1-7 setae and no scales; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 27-32 setae in caudal group, 5-14 in basal, the latter group separated mesally; tergum VII 0.36 length distal half ovipositor.

Pupa. Antennal horns short, simple, with short caudoventral prominences. Frons with ridges immediately caudal of antennal horns and with pair of small projections lateral of clypeal base.

Holotype, male, 6 mi W Burley, Cassia Co, Idaho, IV-22-1968, Artemisia tridentata, R. G. Jones, USNM Type No. 66634.

Biology

Seasonal occurrence. Immature larvae were found at Site 27 on March 8, 1970 coinciding with the first sign of gall development. Pupae were found on May 14, 1969 at Site 1 on A. t. tridentata and at Site 4 on May 29, 1969 on A. t. vaseyana. Adults emerged May 19, 1969 from galls collected on May 14 at Site 1. A pupal exuvium was found at the apex of each gall's hollow portion.

Gall

Description and development. This bud gall (Fig. 23) develops in the spring when plant growth begins. It is green and appears to be made up of a series of fused leaves that form a woody, hollow structure that is open apically. The inner surface of the gall is densely clothed with long trichomes while the outer surface is covered with shorter trichomes. The base of the gall contains a single larval chamber. Some developing galls (Fig. 24) are short and dark reddish. After adults emergence the woody gall dries and persists on the plant for a year or longer.

Eighteen mature galls from *A. t. vaseyana* "f. *xericensis*" and *A. t. wyomingensis* ranged in length from 10-19 mm (avg. 12). The basal diameter ranged from 4-6 mm (avg. 4). Three galls from *A. t. tridentata* had respective lengths of 15, 17 and 25 mm and all with a basal diameter of 3 mm.

Effect on the plant. This gall formation ends normal growth from a bud but was never found abundant enough to cause branch mortality.

Associated insects

Chalcidoidea. A species of *Tetrastichus* was reared from this gall type.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Cassia Co: 6 mi W Burley, 4240 ft (holotype, male, and pupal exuviam, paratype); Gooding Co: 9 mi W Bliss, 3000 ft; Twin Falls Co: 5 mi E Twin Falls, 3746 ft (male, female, paratypes).

A. tridentata tridentata: IDAHO: Lincoln Co: 11.5 mi W Kimama, 4275 ft; Owyhee Co: Hot Creek Falls (3 pupae, paratypes).

A. tridentata vaseyana: IDAHO: Twin Falls Co: 17 mi S Hansen, 4725 ft.

A. tridentata vaseyana "f. *xericensis*": IDAHO: Washington Co: 8 mi N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (3 pupae paratypes); Gooding Co: 9 mi NW Bliss (pupa, paratype); Lincoln Co: 12 mi W Kimama (pupa, paratype); Owyhee Co: 3 mi SW Walter's Ferry (2 pupae, paratypes); Twin Falls Co: 8 mi N Roseworth, 4800 ft (female, paratype).

Rhopalomyia cramboides Gagné, new species

(Figs. 25, 26, 57, 58, 86, 87)

Diagnosis

Rhopalomyia cramboides is a fairly large species with 1-segmented palpi and toothed claws. The pupa resembles that of *R. gossypina* and *R. anthoides*, two other species that are responsible for cabbage-like galls on *Artemisia* plants. The three species differ from one another mainly in the male genitalia: *R. cramboides* has a small basimeral lobe unlike the large one found in *R. gossypina* and a short-ovoid, wide-toothed telomere as compared to the humpbacked, narrow-toothed one of *R. anthoides*.

Description

Male. Wing length, 2.5-2.9 mm. Eyes less than 1 facet diameter apart at vertex. Antenna with 13-14 flagellomeres; neck flagellomere III, 0.74-0.81 length node; neck V, 0.77-0.81 length node; neck VII, 0.76-0.84 length node. Fused labella small, hemispherical in frontal view, 0-4 setae per labellum. Palpus 1-segmented, elongate-ovoid, with 0-3 setae. Frontoclypeus with 2-5 setae per side. Anepimeron with 4-7 setae. Claws toothed, tooth weak. Abdoment: tergum III with 6-10 setae per side, V with 7-13, VII with 10-17, and VIII with 6-12, and few scales interspersed with setae on the last, and the 2 setal groups not contiguous; pleura II-VI naked, VII with 2-3 setae, and

VIII with 6-8 setae and several scales; sterna II-VII each with bsal pair of trichoid sensilla, sternum VII with 22-28 setae in distal group and 24-30 in basal. Genitalia (Figs. 86-67): basimere long, tapering fairly gradually from wide base to narrower apex, with small, distinct lobe at distal two-thirds; telomere elongate-ovoid, tooth wide; sternum X concave apically.

Female. Wing length, 1.4-1.8 mm. Antenna with 11-13 flagellomeres; neck flagellomere III, 0.19-0.22 length node; necks V, VII 0.18-0.21 length node; necks indistinct or absent beyond IX. Other head and thoracic characters as in male. Abdomen: tergum III with 3-5 setae per side, V with 7-9, and VII with 6-8, the setal groups not contiguous mesally, pleura II-VI naked, VII with 0.2 setae and no scales; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 10-15 setae in distal group and 14-17 in basal, the second group divided into three distinct subgroups; tergum VII 0.28-0.31 length distal half of ovipositor.

Pupa (Figs. 57-58). Antennal horns short, the posteroventral corner weakly produced. Frons with short ridge present immediately caudal of each antennal horn and with small pair of frontal projections lateral of base of clypeus.

Holotype, male, 4 mi W Almo, Cassia Co., IV-22-1969, Artemisia tridentata vaseyana, R. G. Jones, USNM Type No. 66635.

Biology

Seasonal occurrence. Pupae were collected on April 22, 1969 at Site 13. At this time the first pair of ephemeral leaves was developing but not yet separate in the bud. In the field adults had emerged by May 6, 1969 at Site 13, and pupal exuviae were still attached to the galls. Adults emerged on April 24, 1969 from galls collected on April 22 at the same site. The earliest collections of immature larvae were on June 2, 1969 at Site 4 and June 30, 1969 at Site 13.

Galls with emerging adults were caged with three individually potted plants of A. t. vaseyana on April 25, 1969. By early September, five galls, similar in appearance to galls found in the field, were found developing on one plant. No gall development occurred on the other plants.

Gall

Description and development. This gall develops from the buds forming on new stem growth. It has a broad base made up of several whorls of fused and stunted leaves subtended by a pair of normal ephemeral leaves (Fig. 25). The outermost leaves are as wide as long while the inner leaves are oblong. The gall is green and normally covered with trichomes. The sclerenchymatous larval capsules in the mature gall are located at the bases of the innermost leaves at the stem apex. These galls are commonly found in clusters on a single branch.

Fifty mature galls had a width (diameter at widest point) ranging from 5-12 mm (avg. 9) and a height (base of gall to leaf apices) ranging from 5-12 mm (avg. 8). There are 1-8 sclerenchymatous capsules per gall (avg. 3).

The developing galls, containing early instar larvae, differ from mature galls only in size. The gall usually attains maximum size by winter although some growth may occur in the following spring. After midge emergence the galls begin to dry and within a year the leaves are lost but the galls persist indifinitely as dark, woody bodies on branch tips of the plants.

Effect on the plant. A large concentration of galls on a branch causes branch mortality (Fig. 26). Although no plant mortality was observed, several plants had lost half or more of their main branches.

Associated insects

Tephritidae. *Oxyna palpalis* was a common inhabitant of these galls at Site 13. Larvae occurred from at least August 1968 until May 1969 in the developing galls. On June 14, 1968 approximately 40 of 100 galls from which midges had emerged contained prepupa or pupa of this species. Only one gall was found where apparent damage to the midge larvae occurred.

Chalcidoidea. Several species were reared from this gall type, including *Torymus aeneoscapus*, *Tetrastichus* sp. and a species of Pteromalinae. We could not establish which were parasitoids of the midge and which were associated with *O. palpalis*.

Platygasteridae. *Platygaster* sp. emerged from a gall collected on *A. t. tridentata* at Site 9 but from no other collections.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bear Lake Co: 12.4 mi E Montpelier, 6350 ft; Cassia Co: City of Rocks (female, paratype); Clark Co: 4 mi NE Argora; Teton Co: 3 mi S Driggs, 6150 ft; Twin Falls Co: 18 mi E Rogerson, 5700 ft.

A. tridentata tridentata: IDAHO: Butte Co: .5 mi E Arco, 5300 ft (2 females, paratypes); Minidoka Co: 2 mi E Acequia, 4200 ft.

A. tridentata vaseyana: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft. (holotype, male, and 7 males, and pupa, paratypes); Twin Falls Co: 17 mi S Hansen, 4725 ft (specimens reared); 22 mi S Hansen, 5700 ft; Rock Creek Canyon (3 males, pupal exuviam, paratypes).

Rhopalomyia anthoides Gagné, new species
(Figs. 27, 28, 88, 89)

Diagnosis

The bud galls of *R. anthoides* superficially resemble those of *R. florella.* The adults however, are quite different in the shape of the male genitalia; also the tarsal claws are toothed in *R. anthoides* and single in *R. florella*. Adults are similar to those of *R. culmata,* which makes a gall on the ephemeral leaves.

Description

Male. Wing length, 2.6-2.9 mm. Eyes less than 1 facet diameter apart at vertex. Antenna with 15-16 flagellomeres; neck flagellomere III, 0.61-0.65 length node; neck V and VII, 0.62-0.70 length node. Fused labella elipsoid, lmost triangular, in frontal view, each labellum with 2-4 setae. Palpus 1-segmented, elongate-ovoid, with 1-2 setae. Frontoclypeus with 4-7 setae per side. Mesanepimeron with 7-15 setae. Claws toothed, the teeth occasionally bifid. Empodia slightly shorter than claws. Abdomen: tergum III with 11-21 setae per side, V with 11-20, VII with 12-19, and VIII with 11-15, the two groups on VIII contiguous mesally; pleura I-VII naked, VIII with 5-8 setae and a few scattered scales; sterna II-VII each basal pair of trichoid sensilla, sternum VII with 20-25 setae in distal group, 18-33 in basal, these continuous across sternum. Genitalia (Figs. 88-89): basimere short, stout, tapering gradually from base to apex; telomere large, elongate-cylindrical, tooth narrow, longer than wide; sternum X truncate.

Female. Wing length, 2.3-2.9 mm. Antenna with 15-17 flagellomeres; neck flagellomere III, 0.20-0.30 length node; neck V, 0.14-0.26 length node; neck VII, 0.12-0.21 length node; necks indistinct beyond VIII-IX. Other head and thoracic characters as in male. Abdomen: tergum III with 10-20 setae per side, V with 12-21, and VII with 8-16; pleura I-VI naked, VII with 4-6 setae and no scales; sterna II-VII each with basal pair of trichoid sensilla; sternum VII with 19-28 setae in distal group and 14-36 in basal the latter group usually divided mesally; tergum VI 0.34-0.42 length distal half ovipositor.

Pupa. Antennal horns short, the posteroventral corner weakly produced. Frons with short ridge present immediately caudal of each antennal horn and with small pair of frontal projections lateral of clypeal base.

Hologype, male, 3 mi N Mt. Home, Elmore Co., Idaho, III-24-1969, Artemisia tridentata, R. G. Jones, USNM Type No. 66636.

Biology

Seasonal occurrence. Immature larvae were found June 10, 1968 at Site 15 coinciding with the first sign of gall development. The larvae appeared to have reached maturity by late November or early December and completely filled their individual sclerenchymatous capsules.

In the field, adults had emerged before April 14, 1969 at Site 15 from A. t. wyomingensis. Adults emerged from March 21 to 26, 1970 from galls collected at the above site on March 18 and or March 28-29 from galls collected at Site 6 on A. t. vaseyana.

Gall

Description and development. This bud gall has a seasonal occurrence similar to that of R. cramboides. In appearance it differs by being longer and less rounded and in structure by having the leaves composing the rosette more linear. In addition, the long outer leaves surround the shorter leaves of the gall base. All leaves of this gall on A. t. wyomingensis have a proliferation of long trichomes especially at their base (Fig. 27) while the leaves on A. t. vaseyana gall have a trichome proliferation only on the inner leaves (Fig. 28).

Eighty-four mature galls from A. t. wyomingensis at Sites 15 and 16 had a basal diameter ranging from 4-15 mm (avg. 8) and a height (length of outer leaves) ranging from 5-17 mm (avg. 11). Fifty-nine of these galls had 1-49 sclerenchymatous larval capsules (avg. 4).

Developing galls differ from mature galls mainly in size. Maximum size of the gall appears to be attained by winter. Following adult emergence in spring the galls dry out and darken in color but persist on the plant a year or longer.

Effect on the plant. With the formation of this gall all normal bud growth ceases. Several small branches were found filled by the concentration of many galls, but no major branch mortality was observed.

Associated insects

Tephritidae. Oxyna palpalis is a common inquiline in the galls of R. anthoides. Up to five puparia of this inquiline were found in old galls.

Chalcidoidea. The following were reared from this gall: Torymus aeneoscapus, Tetrastichus sp., a spcies of Pteromalinae and a species of

Encyrtidae. Their specific hosts were not established.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bear Lake Co: 9 mi S Dingle, 6300 ft, Butte Co: 21 mi SW Arco; 6000 ft; Camas Co: 6 mi W Hill City, 5400 ft; Clark Co: 3.5 mi W Dubois, 5150 ft; 8 mi N Small, 5960 ft; Elmore Co: 9 mi W Bliss, 3000 ft; Madison Co: 9 mi W Rexburg, 4850 ft; Owyhee Co: 27 mi S Bruneau, 4650 ft; 5 mi E. Murphy, 2900 ft; 14 mi S Riddle, 5300 ft; Twin Falls Co: 8 mi SW Rogerson, 6200 ft; NEVADA: Washoe Co: 12 mi SW Reno, UTAH: Cache Co: 20 mi E Logan.

A. tridentata tridentata: IDAHO: Butte Co: .5 mi W Arco, 5300 ft; Owyhee Co: 2 mi S Riddle, 5300 ft; WASHINGTON: Garfield Co: 14 mi W Clarkston.

A. tridentata vaseyana: IDAHO: Camas Co: 11 mi N Fairfield, 6500 ft; Twin Falls Co: 17 mi S Hansen, 4725 ft (2 females, paratypes); 21 mi S Hansen, 5240 ft; 22 mi S Hansen, 5700 ft (2 males, 2 females, paratypes); 17 mi E Rogerson, 5700 ft.

A. tridentata vaseyana f. *spiciformis*: IDAHO: Camas Co: 16 mi N Fairfield, 7000 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (2 females, paratypes); 7 mi S Mt. Home, 3000 ft (holotype, male).

Rhopalomyia florella Gagné, new species

(Figs. 29, 59, 60)

Diagnosis

Rhopalomyia florella is quite distinct from the other three species that form generally similar galls, viz. *R. cramboides*, *R. anthoides* and *R. gossypina*. Unlike the other species, adults of *R. florella* have simple tarsal claws with the males having a short but prominent mesoventral lobe on the basimere. The pupa is unique because of the ventrobasal spur on the antennal horn.

Description

Male. Wing length, 1.9-2.1 mm. Eyes contiguous at vertex. Antenna with 14 flagellomeres; neck flagellomere III, 0.48-0.53 length node; neck V, 0.52-0.61 length node; neck VII, approximately 0.56 length node. Fused labella ellipsoid, with 5-9 setae. Palpus 1-segmented, elongate-ovoid, with 2-4 setae. Frontoclypeus with 8-17 setae. Anepisternum with 13-16 setae. Claws strongly curved, simple. Empodia as long as claws. Abdomen: tergum III with 9-11 setae per side, V with 9-13, VII with 16-20, and VIII with 14-16 setae and a few scales, of VII and VIII contiguous mesally; pleura I-V naked, VI with 2-3 setae, VII with 4-7, and VII with 12-14 setae and several scales; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 16-20 setae in caudal groups, 14-17 in basal, these continuous across sternum. Genitalia: basimere with small mesoventral lobe at base, narrow beyond; telomere ovoid with wide tooth, sternum X slightly concave apically.

Female. Wing length, 1.1-1.2 mm. Eyes almost continguous at vertex. Antenna with 12 flagellomeres; necks short to indistinct, none beyond flagellomere III. Labella without setae. Palpus with 0-3 setae. Frontoclypeus with 4 setae per side. Anepisternum with 4-5 setae. Frontoclypeus with 4 setae per side. Anepisternum with 405 setae. Abdomen: tergum III with 507 setae, V with 6-8, VII with 5-7; pleura naked; sterna

II-VII usually with two basal trichoid sensilla, sternum VII with 11-15 setae in caudal group, 7-10 in basal; tergum VII 0.20-0.25 length distal half ovipositor.

Pupa (Figs. 59-60). Antennal horn with short, ventrally pointed apex and long caudoventral spur. Frons short with two lateral projections.

Holotype, male, 3 mi N Mt. Home, Elmore Co., Idaho, III-25-1970, *Artemisia tridentata wyomingensis*, R. G. Jones, USNM Type No. 66637.

Biology

Seasonal occurrence. Adults emerged on March 25 and 26, 1970 from galls collected on March 18 at Site 15.

Gall

Description. This rosette bud gall (Fig. 29) is similar to that of *R. anthoides*. In general structure and in plant parts affected it appears identical. However, it differs by having the inner leaves similar in length to the leaves of the outer whorls. In addition, galls on both *A. t. vaseyana* (Fig. 29) and *A. t. wyomingensis* have a proliferation of long trichomes on all leaves. In size the gall of *R. florella* is about the same as the smaller galls of *R. anthoides*.

Effect on the plant. All normal growth from a bud is terminated with gall formation. Concentrations of old dry galls persisting on plants indicate that some small branch mortality is caused.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Owyhee Co: 40 mi SE Bruneau

A. tridentata tridentata: IDAHO: Butte Co: 7 mi E Howe (7 females, 2 pupal exuvia, paratypes).

A. tridentata vaseyana: IDAHO: Owyhee Co: 2 mi N Riddle, 5400 ft.

A. tridentata wyomingensis: IDAHO: Butte Co: 8 mi E Arco (male, 4 pupal exuvia, paratypes); Elmore Co: 3 mi N Mt. Home, 3325 ft. (holotype male, 4 males and 2 females, paratypes).

Rhopalomyia conica Gagné, new species
(Figs. 30, 31, 61, 62)

Diagnosis

This species closely resembles *R. cramboides* with its 1-segmented palpus, toothed claws, and short basimeral lobe. The tarsal claws have smaller teeth in *R. cramboides* than they do in *R. conica*. The pupa resembles that of *R. cramboides*.

Description

Male. Wing length, 2.4-2.7 mm. Eyes contiguous at vertex. Antenna with 14-15 flagellomeres; neck flagellomere III, 0.72-0.81 length node; necks V and VII, 0.68-0.81 length node. Fused labella hemispherical in frontal view, with

3.13 setae per labellum. Palpus 1-segmented, ovoid, with 3-10 setae. Frontoclypeus with 5-8 setae per side. Anepisternal setae 5-16. Claws toothed, the teeth strong, occasionally bifid. Abdomen: tergum III with 10-20 setae per side, V with 15-21, VII with 13-20, and VIII with 19-26 setae and several scales, the setal groups of tergum VIII contiguous mesally; pleura I-V with 0-5 setae; VI with 4-8, VII with 9-14, and VIII with 15-21 setae and no scales; sterna II-VII with basal pair of trichoid sensilla, sternum VII with 21-30 setae in caudal groups and 19-31 in basal. Genitalia: basimere with small mesobasal lobe, otherwise tapering gradually from base to narrower apex; telomere ovoid, tooth wide; caudal margin sternum X straight to concave.

Female. Wing length, 1.4-1.8 mm. Antenna with 13-15 flagellomeres; neck flagellomere III, 0.21-0.32 length node, necks V and VII, 0.11-0.24 length node, necks indistinct beyond VIII-IX. Other head and thoracic characters as in male. Abdomen: tergum III with 9-16 setae per side, V with 11-22, and VII with 11-15; pleura I-V without setae, VI with 0-2, and VII with 5-10 setae and no scales; sterna II-VII with basal pair of trichoid sensilla; sternum VII with 21-30 setae in caudal groups, 18-22 in basal, this group divided into three distinct subgroups; tergum VII 0.30-0.33 length distal half ovipositor.

Pupa. (Figs. 61-62). Antennal horns short, the posteroventral corner weakly produced. Fronts with short ridge immediately caudal of each antennal horn and with or without short pair of frontal projections lateral of clypeal base.

Holotype, male, 5 mi E Twin Falls, Twin Falls Co, Idaho, V-14-1968, *Artemisia tridentata*, R. G. Jones, USNM Type No. 66638.

Biology

Seasonal occurrence. Immature larvae were found in late March 1970 at Site 23 coinciding with the first sign of developing galls. A collection of mature larvae was made at this site on May 6, 1969. Pupae were collected from galls on *A. t. wyomingensis* at Site 21 on April 21, 1969 and from *A. t. tridentata* at Site 1 on April 23, 1969. In the field, adult emergence coincided with that of *R. pomum* at Sites 1 and 2. Adults emerged from April 20-24, 1969 from galls collected April 14 at Site 15. From another collection of galls made on May 14, 1969 from *A. t. tridentata* at Site 1, adults emerged on May 15-16.

Gall

Description and development. This bud gall is monothalamous. The mature gall is green and covered with trichomes. The larval capsule has a yellowish translucent sclerenchymatous surface. On *A. t. tridentata* the prominent sclerenchymatous larval capsule of the mature gall (Fig. 30) is surrounded by a whorl of basally fused leaf vestiges around which are several whorls of linear or spatulate leaves that gradually increase in length outwardly. The gall is irregularly rosette in form. On both *A. t. vaseyana* "f. *xericensis*" and *A. t. wyomingensis* the mature gall (Fig. 31) is more normally rosette. The sclerenchymatous larval capsule is sourrounded by several whorls of equally long, ovate leaves.

Thirty-one mature galls collected at Site 1 and 2 on *A. t. tridentata* had a diameter (measured at base including inner whorl of leaves) ranging from 3-6 mm (avg. 4). The sclerenchymatous capsules of these galls had a length range of 3-4 mm (avg. 3.2) and the width or diameter of each was approximately 1 mm. The diameter (measured across the apices of the outer leaves) of 26 mature galls collected at Sites 15 and 21 from *A. t. wyomingensis* ranged from 8-21 mm (avg. 9.41). The capsule measurements were the same as those from *A.*

t. wyomingensis, of 17 mature galls from A. t. vaseyana "f. xericensis" ranged from 10-16 mm (avg. 13). The capsule lengths ranged from 3-5 mm with diameters of approximately 1 mm.

Developing galls occur with the initiation of spring plant growth. On A. t. wyomingensis the developing gall was first found seasonally on March 23, 1970 at Site 12 and on A. t. vaseyana "f. xericensis" the following day at Site 27. The galls dry shortly after midge emergence the following spring and persist on the plant into at least late summer. Galls from which emergence has occurred are readily recognized by the protruding larval capsule that is broken apically.

Effect on the plant. Normal stem growth at the bud was prevented by the formation of this gall, but the overall effect on plants was minimal since galls were not concentrated but generally distributed over the plant.

Associated insects

Platygasteridae. Platygaster utahensis and Platygaster sp. were found to parasitize this midge species.

Chalcidoidea. Tetrastichus sp. was reared from the larval capsules of these galls.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bear Lake Co: 9 mi S Dingle, 6300 ft; 12.4 mi E Montpelier, 6350 ft; Blaine Co: 3 mi W Carey, 5150 ft; Cassia Co: 8 mi SE Albion, 5350 ft; 4 mi W Almo, 6200 ft; Franklin Co: 1.5 mi W Dayton, 4750 ft; Lincoln Co: 25 mi N Shoshone, 4960 ft; 5 mi NE Shoshone, 4000 ft; Twin Falls Co: 18 mi E Rogerson, 5700 ft; NEVADA: Pershing Co: 4 mi N Mill City.

A. tridentata tridentata: IDAHO: Canyon Co: 15 mi S Nampa, 2350 ft; Elmore Co: Hot Springs, 9 mi NE Mt. Home (pupa, paratypes); Gooding Co: 5.5 mi E Gooding, 3800 ft (4 females, 5 pupae, paratypes); 5 mi N Hagerman (2 females, 2 pupae, paratypes); Lemhi Co: 16 mi N Salmon, 4000 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft; 10.5 mi NE Richfield, 4700 ft; Owhyhee Co: 4 mi NW Murphy, 2800 ft; Twin Falls Co: 11 mi S Hansen, 4300 ft; 5 mi E Twin Falls, 3746 ft (holotype male, female, pupal exuvia, paratypes); 5.5 mi E Twin Falls, 3650 ft; 6 mi NE Twin Falls, 3700 ft; WASHINGTON: Franklin Co: Palouse Falls State Park (2 males, paratypes).

A. tridentata vaseyana: IDAHO: Valley Co: 6 mi N Cascade, 4700 ft.

A. tridentata vaseyana "f. xericensis": IDAHO: Washington Co: 8 mi N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (male, 4 females, pupa, pupal exuvia, paratypes) (specimens reared); Gooding Co: 9 mi W Bliss, 3000 ft (3 females, paratypes).

A. arbuscula: IDAHO: Bear Lake Co: 12.4 mi E Montpelier, 6350 ft.

A. nova: IDAHO: Cassia Co: 8 mi SE Albion, 5350 ft.

A. tripartita: IDAHO: Bear Lake Co: 3 mi N Georgetown, 6200 ft.

Rhopalomyia mammilla Gagné, new species
(Figs. 32, 63, 64)

Diagnosis

Adults of R. mammilla have 1-segmented palpi, toothed claws and the males have a large ventrobasal lobe on the basimere. This species is closely related to R. hirticaulis. Adults differ chiefly in shape of the telomere which, in R. mammilla, tapers gradually from the wide base to the long apical tooth; pupae differ only in the R. mammilla has slightly longer antennal horns.

Description

Male. Wing length, 2.1-2.2 mm. Eyes contiguous at vertex. Antenna with 14-15 flagellomeres; neck flagellomere III, 0.42-0.48 length node; necks V and VII, 0.53-0.58 length respective nodes. Fused labella ellipsoid, 2-7 setae per labellum. Paupus 1-segmented, elongate-ovoid, with 3-6 setae. Frontoclypeus with 1-6 setae. Anepisternum with 4-7 setae. Claws toothed. Abdomen: tergum III with 11-23 setae per side, V with 11-22, VII with 13-27, and VIII with 11-15 setae and no scales, the setal groups of VIII contiguous mesally; pleura I-V with 0-3 setae, VI with 3-7, VII with 7-10 and several scales, and VIII with 15-19 setae and scattered scales; sterna II-VII each with basal pair of trichoid sensilla; sternum VII with 29-34 setae in caudal group and 26-32 in basal. Genitalia: basimere with large basoventral lobe; telomere elongate-cylindrical, tapering gradually from base to narrow tooth; sternum X margin convex apically.

Female. Wing length, 1.4-1.7 mm. Antenna with 13-14 flagellomeres; necks indistinct. Other head and thoracic characters as in male. Abdomen: tergum III with 6-9 setae, V with 5-12, and VII with 11-13; pleura I-V naked, VI with 1-3 setae, and VII with 3-5; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 18-24 setae in caudal group, 12-17 in basal, the latter group divided into three subgroups; tergum VII approximately 0.38 length distal half ovipositor.

Pupa (Figs. 63-64). Antennal horn produced ventrally with an anteroventral projection and a small basal spur. Frons with pair of triangular projections at level of clypeal base. Pronotum long, greatly extended ventrally between antennal horns.

Holotype, male, 15 mi NW Blackfoot, Bingham Co., Idaho, IX-9-1968, Artemisia tridentata, R. G. Jones, USNM Type No. 66639.

Biology

Seasonal occurrence. Adults emerged September 10-17, 1968 from galls collected on September 9 at Site 14. On the collection date the host plants were in early bloom.

Gall

Description and development. This polythalamous rosette gall (Fig. 32) grows from a bud on the current year's stem and is subtended prior to maturity by two or more ephemeral leaves. It is composed of several whorls of mostly equal, linear to acicular leaves surrounding two to four sclerenchymatous larval capsules.

The basal diameter of one measured gall was 6 mm. Its outer leaves were up to 10 mm in length and the other leaves approximately 5 mm in length.

Associated insects

Platygasteridae. Platygaster sp. was reared from galls of this species.

Chalcidoidea. Torymus aeneoscapus represented the only species of this superfamily reared from galls of *R. mammilla*.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bingham Co: 15 mi NW Blackfoot (holotype male and female, paratype).

A. tridentata tridentata: IDAHO: Cassia Co: 4 mi E Idahome, 4400 ft.; 8 mi SE Malta, 4400 ft; Twin Falls Co: 5 mi E Twin Falls, 3746 ft

A. tridentata vaseyana: IDAHO: Custer Co: 8 mi NW Mackay, 6200 ft (2 males, 6 females, 3 pupae, paratypes); Twin Falls Co: 17 mi S Hansen, 4725 ft; 22 mi S Hansen, 5700 ft.

A. tridentata wyomingensis: IDAHO: Lemhi Co: 1 mi NE Baker, 4500 ft.

Rhopalomyia obovata Gagné, new species
(Figs. 33, 43, 44, 65, 66, 94, 95)

Diagnosis

This species is one of the largest and more robust of the *Artemisia* associated midges and, like most of the other large species, has 2-segmented palpi and toothed claws. The distinctive male genitalia and the pupal head with its pronounced conical antennal horns set *R. obovata* apart from all other *Artemisia* associated midges except *R. nucula*. This species differs from the latter in the absence of scales from most of the abdominal pleura, the wider male telomere tooth, and the relatively more pronounced pronotum and antennal and facial horns of the pupa. Also, larvae of *R. obovata* have three pairs of terminal papillae and those of *R. nucula* have only one pair.

Description

Male. Wing length, 3.3-3.5 mm. Eyes separated at vertex by 1-3 facets diameter. Antenna with 16-17 flagellomeres; neck flagellomere III, 0.54-0.56 times length node; neck V, 0.57-0.60 length node; neck VII, 0.57-0.73 length node. Fused labella hemispherical in frontal view, usually naked, occasionally with one seta per labellum. Palpus 2-segmented, the segments subequal in length; naked except for occasional seta on segment I. Frontoclypeus with 3-14 setae per side. Anepisternum with 9-15 setae. Claws strong, each with strong tooth, the latter occasionally bi- or trifid on one or more legs. Empodia approximately as long as claws. Abdomen: tergum III with 17-35 setae per side, V with 20-48, VII with 19-46, and VIII with 16-31, the two groupos of setae on tergum VII contiguous mesally; pleura I-VI without setae or scales; VII with 0-4 setae, VIII with 0-7 setae; sterna II-VII each with basal pair of trichoid sensilla, sternum VII usually without sensilla occasionally with one, sternum VII with 32-44 setae in distal group, 22-39 in basal group, these continuous across width of sternum. Genitalia (Figs. 94-95): basimere short, stout, in lateral view much wider basally than apically, small mesoventral lobe inconspicuous in lateral view; telomere elongate cylindrical, tapering abruptly at wide apical tooth; sternum X slightly to deeply bilobed.

Female. Wing length, 2.5-2.6 mm. Eyes almost contiguous at vertex, separated by less than 1 facet diameter. Antenna with 15 flagellomeres; neck flagellomere III, 0.25-0.27 length node; neck V, 0.22-0.26 length node; neck VII, 0.17-0.24 length node; necks indistinct after flagellomere XI-XII. Other head and thoracic characters as in male. Abdomen: tergum III with 21-28 setae per side, V with 17-24, and VII with 15-23, the two groups of tergum VII setae not continguous mesally; pleura I-VI without setae or scales, VII with 0-2 setae; sterna II-VII each with basal pair of trichoid sensilla; sternum VII with 24-28 setae in distal group, 16-26 in basal group, these in a row reaching across width of sternum or interrupted mesally; tergum VII 0.37 - 0.40 length distal half of ovipositor.

Pupa. (Figs. 43-44, 65-66). Antennal horns long, conical, tapering gradually from base to pointed apex. Frons with two pairs of projections: a pair of transverse ridges immediately caudad of the antennal bases, the anterior surface concave, the posterior convex, and a well developed pair of pointed, bilaterally compressed projections laterad of the base of the clypeus.

Holotype, male, 5 mi. E. Twin Falls, Twin Falls Co., Idaho, III-24-1969, *Artemisia tridentata tridentata*, R. G. Jones, USNM Type No. 66640.

Biology

Seasonal occurrence. Immature larvae were found June 13, 1969 at Site 1 on both *A. t. tridentata* and *A. t. wyomingensis*, coinciding with the first sign of gall development. By late fall the larva reaches maturity. They are a darker orange color than larvae found earlier and they completely fill the sclerenchymatous capsule in the center of the gall. Overwintering occurs at this stage of development. The earliest collections of pupae were made at Site 1 on March 24, 1969 and the latest made May 18, 1968 on *A. t. vaseyana* at Site 8. At both sites spring ephemeral leaf development either had not started or was just discernable. Adults were emerging by March 24, 1969 at Site 1, whereas in 1970 they emerged before March 20 at this site and before March 19 at Site 24. Emergence was in progress as late as May 18, 1968 at Site 8.

Laboratory rearings indicate that adult emergence may occur over a considerable period of time in the field. Adults emerged January 10, 1970, from galls collected on December 29, 1969 from *A. t. vaseyana* "f. *xericensis*" at Site 27, March 24-26, 1969 from galls collected March 24 at Site 1, and May 19-23, 1968 from galls collected at Site 8 on May 18. Altitudinal differences of these sites may be responsible for some of this variation in time of emergence.

Gall

Description and development. This ovoid bud gall has vestiges of spatulate leaves (Fig. 33). Its smooth, green suface is densely covered with trichomes. Maturity is reached in the fall after which degeneration begins. The gall surface dries and hardens, becoming shiny yellow-brown and losing its trichomes and the leaf vestiges. By late fall the tissue beneath the surface layer dries to a hard black mass which surrounds the 1-4 sclerenchymatous larval capsules containing the overwintering larvae. These dry galls persist on either vegetative or flower stems into the following spring until shortly after the midges emerge.

Seventy-eight mature galls from the three subspecies of *A. tridentata* collected at Sites 1, 15, 21 and 27 ranged in diameter from 5-10 mm (avg. 7) and in height from 6-11 mm (avg. 8). No size differences of the galls could be attributed to host plant or location. Ten immature galls collected from *A. t. tridentata* at Site 1 on June 13, 1969 had a diameter ranging from 204 mm (avg. 3).

The developing gall wich first appears as swellings of the bud and leaf base on developing stems differ from the mature gall only in size. When these galls were first evident the ephemeral leaves were near maturity, the new persistent leaves were developing, the old persistent leaves were mostly dry, and flower stems were distinguishable.

Effect on the plant. With gall formation normal growth ceases in the affected bud. Some branch mortality occurs with concentration of galls, but no major damage was observed.

Associated insects

Platygasteridae. *Platygaster* sp. was reared from these galls and found to parasitize this midge.

Chalcidoidea. The following were reared from galls and found to parasitize this midge: *Torymus aeneoscapus*, *Tetrastichus* sp., a species of Pteromalinae and a species of Eupelmidae.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bannock Co: .5 mi W McCammon, 4719 ft; Bear Lake Co: 12.4 mi E Montpelier, 6350 ft; Bingham Co: 15 mi NW Blackfoot; Boise Co: 7 mi S Horseshoe Bend, 4200 ft; 20 mi S Idaho City; Cassia Co: 8 mi SE Albion, 5350 ft; 6 mi W Burley, 4240 ft; Clark Co: 4 mi NE Argora, 7250 ft; 3.5 mi W Dubois, 5150 ft; Custer Co: 4 mi SW Clayton, 5000 ft; Elmore Co: 9 mi W Bliss, 3000 ft; 7 mi S Mt. Home, 3000 ft; Owyhee Co: 27 mi S Bruneau, 4650 ft; 40 mi SE Bruneau; 28 mi SW Marsing; 5 mi E Murphy, 2900 ft; 6 mi E Murphy, 2900 ft; 3 mi E Reynolds; Power Co: 14 mi W American Falls, 4400 ft; NEVADA: Pershing Co: 4 mi N Mill City; Washoe Co: 16 mi SE Reno.

A. tridentata tridentata: IDAHO: Cassia Co: 4 mi E Idahome, 4400 ft; 6 mi NE Malta, 4400 ft; 8 mi SE Malta, 4400 ft; Gooding Co: 5.5 mi E Gooding, 3800 ft; Lemhi Co: 16 m N Salmon, 4000 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft; Minidoka Co: 2 mi E Acequia, 4200 ft; Owyhee Co: 2 mi W Indian Cove, 2850 ft; 23 mi SW Grandview; Twin Falls Co: 6 mi S Bliss; 11 mi SW Bliss; 5 mi E Twin Falls, 3746 ft (holotype male, 4 males, 3 females, and 2 pupae, paratypes); WASHINGTON: Franklin Co: Palouse Falls State Park.

A. tridentata vaseyana: IDAHO: Blaine Co: 2 mi W Carey (2 pupae, paratypes); Galena Summit viewpoint, 8600 ft (3 males, 7 females, 42 pupae, paratypes); Camas Co: 12 mi S Fairfield, 5450 ft; Custer Co: 8 mi NW Mackay, 6200 ft; 32 mi NW Mackay, 6425 ft; Pass Creek Summit, 7633 ft; Elmore Co: Little Camas Res. (female, paratype); Gooding Co: 16 mi N Gooding, 5225 ft; Lemhi Co: Bannock Pass Summit, 7672 ft; 10 mi E Leadore; Oneida Co: 9.5 mi W Malad, 5200 ft; Twin Falls Co: 17 mi E Rogerson, 5700 ft; Valley Co: 6 mi N Cascade, 4700 ft; Washington Co: 4 mi S Midvale, 3200 ft.

A. tridentata vaseyana "f. *xericensis*": IDAHO: Washington Co: 8 mi N Weiser, 2850 ft.

A. tridentata wyomingensis: IDAHO: Canyon Co: 15 mi S Nampa, 2500 ft; Elmore Co: 3 mi N Mt. Home, 3325 ft (specimens reared); Gooding Co: 12 mi N Gooding, 4400 ft; 3 mi S Hagerman, 2964 ft; Lemhi Co: 1 mi NE Baker, 4500 ft; Lincoln Co: 12 mi W. Kimama, 4275 ft; Owyhee Co: 5 mi N. Reynolds, Twin Falls Co: 8 mi N Roseworth, 4800 ft; 4 mi E Twin Falls, 3746 ft (specimens reared).

A. arbuscula: IDAHO: Bear Lake Co: 12.4 mi E. Montpelier, 6350 ft; Clark Co: 18 mi NW Terreton, 4800 ft.

A. nova: IDAHO: Butte Co: 19.9 mi NE Howe, 5100 ft; Cassia Co: 8 mi SE Albion, 5350 ft; 3 mi NW Malta, 4400 ft.

A. tripartita: IDAHO: Bannock Co: .5 W McCammon, 4719 ft.

Rhopalomyia nucula Gagné, new species
(Figs. 34, 35)

Diagnosis

This species is close to *R. obovata*. The pupae of both species are very similar, but adults may be separated by the abdominal setation and shape of the male telomere. The tooth of the latter is narrower in *R. nucula* than in *R. obovata*. As evident from their descriptions the galls of these two species are very different.

Description

Male Wing length, 2.6-3.1 mm. Eyes separated at vertex by 1.0-1.5 facets diameter. Antenna with 15-16 flagellomeres; neck flagellomere III, 0.45-0.55 length node; neck V, 0.45-0.51 length node; and neck VII 0.50-0.55 length node. Fused labella hemispherical in frontal view, occasionally indented mesally, 0-1 setae per labellum. Palpus 2-segmented, segment II generally longer, usually about twice length I, 1-4 setae per segment. Frontoclypeus with 3-8 setae per side. Anepisternum with 14-29 setae. Claws strong toothed, the latter occasionally bi- or trifid on one or more legs. Empodia approximately as long as claws. Abdomen: tergum III with 12-17 setae per side, V with 10-17; VII with 12-19, and VIII with 7-13, the two lateral groups not contiguous mesally; pleura with a few setae on segment VIII only, but all segments covered with scales; sterna II-VII each with a basal pair of trichoid sensilla; sternum VII with 19-34 setae in caudal group, 30-55 in basal group, the latter undivided mesally. Genitalia; basimere short, stout, in lateral view much wider basally than apically, small mesoventral lobe inconspicuous in later view; telomere elongate-cylindrical, tapering abruptly at apical tooth, the latter approximately 0.5 width telomere at widest; sternum X slightly to deeply bilobed apically.

Female. Wing length, 2.1-2.4 mm. Antenna with 14-15 flagellomeres; neck flagellomere III, 0.30-0.32 length node; neck V, 0.29 length node; neck VII, 0.03-0.22 length node; necks indistinct beyond flagellomere VIII. Other head and thoracic characters as in male. Abdomen: tergum III with 11-22 setae per side, V with 10-19, and VII with 9-15 the lateral groups of tergum VII not contiguous mesally; pleura without setae, but scales numerous on all segments; sterna II-VII each with two basal trichoid sensilla; sternum VII with 16-30 caudal setae and 14-22 basal setae, these divided mesally into two lateral groups; tergum VII 0.36-0.39 length distal half of ovipositor.

Pupa. Antennal horns long, conical, tapering gradually from base to pointed apex. Frons with a pair of low, convex bumps immediately caudad of antennal bases, and a pair of pointed, bilaterally compressed projections laterad of base of the clypeus.

Holotype, male, 5 mi E Twin Falls, Twin Falls Co., Idaho, III-20-1970, *Artemisia tridentata*, R. G. Jones, USNM Type No. 66641.

Biology

Seasonal occurrence. Immature larvae were found on *A. t. wyomingensis* June 10, 1968 at Site 15, coinciding with the first sign of gall development. Larvae also were collected on both *A. t. tridentata* and *A. t. wyomingensis* June 13, 1969 at Site 1. Larvae were found through the summer and fall and into the following spring. Mature larvae were present on April 17, 1969 on *A. t. tridentata* at Site 23. Pupae were collected April 17, 1969 at Site 23 and in 1970 on March 20 at Sites 1 and 3. At the time of these collections the first whorls of ephemeral leaves had begun spring growth. Field observation showed that adults had emerged by March 20, 1970 at Site 1 and prior to March 23, 1970 at Site 21. Adults emerged on April 12, 1969 from galls collected on March 24 at Site 1, and the following year they emerged on March 29 and 31, 1970 from galls collected on March 20 at Site 4 and on April 19, from galls collected April 17 at Site 23.

Gall

Description and development. The white or gray polythalamous gall (Fig. 34) appears to be a concentration of individual, ovoid galls (Fig. 35) that form a globuliferous mass around a stem. The gall is a firm mass of plant tissue with centrally located larval chambers. The surface is densely clothed with long trichomes giving it a fuzzy appearance.

Sixty-three mature galls collected from A. t. tridentata and A. t. wyomingensis at Sites 1, 21 and 24 ranged in width (diameter perpendicular to stem) from 30-15 mm (avg. 9) and in height (diameter parallel to stem) from 3-10 mm (avg. 6). These galls had 1-11 (avg. 5) larval chambers.

Galls develop from summer to the following spring with most noticeable growth occurring before winter. The first sign of the developing gall was in early June when immature larvae were found. At this time epemeral leaves were near full growth, the persistent leaves were nearly dry, and the gall appeared as a small white globose structure at a node. Ten of these developing galls collected on June 18, 1969 at Site 1 ranged in width from 1.5 to 2.5 mm (avg. 1.9). Galls begin to dry and decompose after midge emergence. However, old gray colored galls were observed persisting on plants for at least a year.

Effect on the plant. No extensive damage was observed, but some minor twig or stem mortality occurred with the formation of the gall.

Associated insects

Tephritidae. Oxyna palpalis was reared from galls collected at several sites on A. t. tridentata and A. t. wyomingensis.

Chalcidoidea. Several species were reared from these galls, including Torymus aeneoscapus, Tetrastichus sp., a species of Pteromalinae and a species of Eupelmidae.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Boise Co: 7 mi S Horseshoe Bend, 4200 ft; Butte Co: 21 mi SW Arco, 6000 ft; Cassia Co: 4 mi W Almo, 6200 ft; Elmore Co: 7 mi S Mt. Home, 3000 ft, (9 females, paratypes); Gooding Co: 9 mi W Bliss, 3000 ft; Lemhi Co: 3 mi NE Baker, Owyhee Co: 27 mi S Bruneau, 4650 ft; 40 mi SE Bruneau; Twin Falls Co: 18 mi E Rogerson, 5700 ft; 5 mi E Twin Falls, 3746 ft (holotype male, 3 males, 7 females, 4 pupae, paratypes). NEVADA: Pershing Co: 4 mi N Mill City; Washoe Co: 16 mi SE Reno, 12 mi SW Reno.

A. tridentata tridentata: IDAHO: Butte Co: .5 mi W Arco, 5300 ft; Cassia Co: 4 mi E Idahome, 4400 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft (9 males, 6 females, 9 pupae, paratypes); Minidoka Co: 2 mi E Acequia, 4200 ft (3 males, 5 females, 4 pupae, paratypes); Owyhee Co: 23 mi SW Grandview; Twin Falls Co: 11 mi SW Bliss; 23 mi SW Twin Falls, 4950 ft (specimens reared); MONTANA: Beaverhead Co: 12 mi E Bannock Pass Summit; 17 mi E Bannock Pass Summit; WASHINGTON: Garfield Co: 14 mi W Clarkston.

A. tridentata vaseyana: IDAHO: Blaine Co: Galena Summit viewpoint, 8600 ft (specimens reared); 15 mi NW Ketchum 7500 ft; 6 mi S Ketchum, 55 ft; Camas Co: 12 mi S Fairfield, 5450 ft; Cassia Co: City of Rocks (5 males, female, 6 pupae, paratypes); Elba-Basin Pass Summit; 7 mi E Oakley; Custer Co: Willow Creek Divide, 7160 ft; Owyhee Co: 2 mi N Riddle, 5400 ft; 7 mi E Sheaville, Oregon; Twin Falls Co: 17 mi S Hansen, 4725 ft (5 females, pupa, paratypes); 21 mi S Hansen, 5240 ft; 22 mi S Hansen, 5700 ft; Magic Mt. Ski Area, 6400 ft (2 males, 3 pupae, paratypes) (specimens reared); 21 mi E Rogerson, 7250 ft.

A. tridentata vaseyana "f *xericensis*": IDAHO: Washington Co: 8 mi N Weiser, 2580 ft.

A. tridentata wyomingensis: IDAHO: Elmore Co: 3 mi N Mt. Home, 3325 ft (specimen reared); Gooding Co: 3 mi S Hagerman, 2964 ft; Twin Falls Co: 8 mi N Roseworth, 4800 ft.

A. nova: IDAHO: Cassia Co: 3 mi NW Malta, 4400 ft.

Rhopalomyia medusa Gagné, new species

(Figs. 36, 37, 38, 39, 67, 68)

Diagnosis

Rhopalomyia medusa and *R. medusirrasa* are anatomically indistinguishable as adults, larvae and pupae. However, their galls are sufficiently different to warrant recognition of these species. Although the galls are the same general type, that of *R. medusa* is naked, whereas that of *R. medusirrasa* is thickly covered with long tyrichomes.

These species are similar to *R. pomum* and *R. calvipomum* in their large size, 2-segmented palpi, toothed claws, and the general shape of the genitalia and pupal heads. The most reliable characters for separating *R. medusa* from *R. pomum* and *R. calvipomum* are the number of trichoid sensilla on the abdominal sterna and the presence or absence of basimeral lobes on the male genitalia.

Description

Male. Wing length, 2.4-3.0 mm. Eyes almost contiguous at vertex, less than 1 facet diameter apart. Antenna with 15-16 flagellomeres; neck flagellomere III, 0.57-0.71 length node; neck V, 0.61-0.76 length node; neck VII 0.63-0.70 length node. Fused labella hemispherical in frontal view; 0-12 setae per labellum. Palpus usually 2-segmented, segment II, if present, 0.5-1.0 length I, either segment with 0-4 scattered setae. Frontoclypeus with 4-14 setae per site. Anepisternum with 11-18 setae. Claws toothed, the tooth occasionally bifid. Empodia approximately as long as claws. Abdomen: tergum III with 18-30 setae per side, V with 16-34, VII with 22-39, and VIII with 17-40, lateral groups of tergum VIII contiguous mesally; pleura I-VI without setae, VII with 0-3, and VIII with 3-10 setae and no scales; sterna II-VII each with two basal trichoid sensilla, sternum VII with 33-42 setae in distal group, 28-48 in basal, the latter continuous across sternum. Genitalia: basimere in lateral view with indistinct lobe tapering gradually from wide base to narrower apex; telomere ovoid with wide tooth; sternum X truncate to bilobed.

Female. Wing length, 1.8-2.3 mm. Antenna with 13-15 flagellomeres; neck flagellomere III 0.10-0.18 length node; neck V, 0.06-0.18 length node; neck VII, 0.06 -0.16 length node; necks indistinct beyond flagellomeres VIII-X. Other head and thoracic characters as in male. Abdomen: tergum III with 11-22 setae per side, V with 11-23, and VII with 14-20, lateral groups of VII contiguous mesally; pleura without setae but with scattered scales on distal segments; sterna II-VII each with basal pair of trichoid sensilla, sternum VII 24-40 setae in distal group, 13-33 in basal, the latter occasionally divided mesally; tergum VI 0.32-0.35 length distal half ovipositor.

Pupa (Figs. 67-68). Antennal horns short, weakly bifid apically with short ventrobasal spur. Frons with pair of angular bilaterally compressed projections.

Holotype, male, 8 mi NW Mackay, Custer Co, Idaho, V-17-1968, *Artemisia tridentata vaseyana*, R. G. Jones, USNM Type No. 66642.

Biology

Seasonal occurrence. Immature larvae were found from early September to early October coinciding with the first sign of gall development. Apparently mature larvae were found on May 15-16, 1969 on *A. t. vaseyana* at Site 6 and on June 15, 1968 on *A. t. vaseyana* f. *spiciformis* at Site 17.

Adult emergence occurred prior to April 21, 1969 at Site 21 from *A. t. wyomingensis* and was still in progress on May 6, 1969 0.5 mi from Site 23. At Site 17 emergence from *A. t. vaseyana* f. *spiciformis* occurred between June 15 and July 11, 1968. At Site 27 adults emerged April 15-19, 1969 from *A. t. vaseyana* "f. *xericensis*" from galls collected on April 8. Emergence occurred from *A. t. wyomingensis* on April 18-19, 1969 from galls collected with pupae present on April 14 at Site 21 and from *A. t. tridentata* on May 10 from galls collected with pupae present on May 6, 1969 at Site 24. The latest emergence was June 18, 1968 from galls collected on June 16 from *A. tripartita* at Site 26 while the earliest was March 28, 1970 from galls collected on March 20 from *A. t. wyomingensis* growing at Site 1.

Gall

Description and development. The mature gall (Fig. 36) consists of a larval chamber (Fig. 37) enclosing in a globular mass of reddish, green, or reddish and green filaments that lack trichomes. The filaments are thickened basally and become thinner, curly and branched distally. Frequently, galls form on several adjacent stem and leaf nodes and encompass large areas of the stem (Fig. 38).

One hundred mature galls from *A. t. tridentata*, *A. t. vaseyana* and *A. t. wyomingensis* collected at Sites 1, 7, 21 and 24 had a diameter (the fibrous mass measured perpendicular to stem) ranging from 8-29 mm (avg. 13.3). Seventy-five of these galls contained 1-3 larval chambers (avg. 1.2). Larger galls were usually observed on more vigorous roadside plants on *A. t. tridentata*.

The first sign of galls was during early September 1968 on both *A. t. tridentata* and *A. t. wyomingensis*. The developing galls were observed on the other host subspecies later in the fall. The galls first appear as groups of tiny leaflike structures growing from the nodes (Fig. 39). Gall development continues during the fall, is arrested during the winter, and continues in the spring with maximum size of the galls reached about the time pupae are present. Stem growth was approximately 2.5-5.0 cm in length by this time at most sites. Within a month after adult emergence the galls become dry and brown. They persist on the host plants for 2-12 months or longer. Developing galls were often found on flower stems but did not reach maturity because these stems died out following bloom in the fall.

Effect on the plant. No stem mortality was found but the presence of many galls appeared to have some effect on the vigor of stem and leaves.

Associated insects

Platygasteridae. Specimens of *Platygaster* spp. were reared from the galls.

Chalcidoidae. *Tetrastichus* sp. and an undetermined species of Peteromalinae were reared from the galls.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Bannock Co: .5 mi W McCammon, 4719 ft; Bear Lake Co: 9 mi S Dingle, 6300 ft; 12.4 mi E Montpelier, 6350 ft; Bingham Co: 5 mi NE Taber; Blaine Co: 3 mi W Carey, 5150 ft; Boise Co: 7 mi S Horseshoe Bend, 4200 ft; 20 mi S Idaho City; Butte Co: 21 mi SW Arco, 6000 ft; Cassia Co: 8 mi SE Albion, 5350 ft (specimens reared); Clark Co: 3.5 mi W Dubois, 5150 ft (male, 6 females, pupa, paratypes); 8 mi N Small, 5960 ft; Custer Co: 5 mi E Clayton, 5650 ft; 4 mi SW Clayton, 5000 ft; Franklin Co: 1.5 mi W Dayton, 4750 ft; Lemhi Co: 3 mi NE Baker; Lincoln Co: 4 mi N Dietrich, 4100 ft; 25 mi N Shoshone, 4960 ft; 5 mi NE Shoshone, 4001 ft; Madison Co: 9 mi W Rexburg, 4850 ft; Owyhee Co: 27 mi S Bruneau, 4650 ft (specimens reared); 40 mi SE Bruneau; 28 mi SE Marsing; 3 mi E Reynolds; 14 mi S Riddle, 5300 ft; Power Co: 14 mi W American Falls, 4400 ft; Twin Falls Co: 11 mi NW Buhl; 18 mi E Rogerson, 5700 ft (male, paratype); 8 mi SW Rogerson, 6200 ft; Teton Co: 3 mi S Driggs, 6150 ft; NEVADA: Pershing Co: 4 mi N Mill City.

A. tridentata tridentata: IDAHO: Gooding Co: 6 mi SE Bliss, 3140 ft (2 males, pupa, paratypes); Lemhi Co: 3.5 mi E Leadore, 5850 ft; Lincoln Co: 11.5 mi W Kimama, 4275 ft (pupa paratype); 10.5 mi NE Richfield, 4700 ft (2 males, 5 females, 12 pupae paratypes); Minidoka Co: 2 mi E Acequia, 4200 ft (male, female, 2 pupae paratypes); Owyhee Co: 2 mi S Riddle, 5300 ft; 23 mi SW Grandview (specimens reared); Twin Falls Co: 11 mi SW Bliss; 5 mi E Twin Falls, 3746 ft (specimens reared); MONTANA: Beaverhead Co: 6 mi E Bannock Pass Summit; 12 mi E Bannock Pass Summit (specimens reared); 17 mi E Bannock Pass Summit (specimens reared).

A. tridentata vaseyana: IDAHO: Blaine Co: Galena Summit viewpoint, 8600 ft (specimens reared); 15 mi NW Ketchum, 7500 ft; 6 mi S Ketchum, 5500 ft (specimens reared); Camas Co: 5 mi N Fairfield, 5150 ft; 9 mi N Fairfield, 6000 ft; 12 mi S Fairfield, 5450 ft; Cassia Co: Elba-Basin Pass Summit; 7 mi E Oakley; Custer Co: 5 mi NW Galena Summit, 7350 ft; 8 mi NW Mackay, 6200 ft (holotype male, 5 males, 2 females, pupa paratypes); 32 mi NW Mackay, 6425 ft; 10 mi S Stanley, 6550 ft; Willow Creek Divide, 7160 ft; Franklin Co: 3 mi W Dayton, 4800 ft (specimens reared); Gooding Co: 16 mi N Gooding, 5225 ft; Lemhi Co: 10 mi E Leadore; Twin Falls Co: 15 mi S Hansen, 4525 ft; 22 mi S Hansen, 5700 ft (specimens reared); 1 mi NW Magic Mt. Ski Area, 6600 ft; 17 mi E Rogerson, 5700 ft; 12 mi E Rogerson, 7250 ft; Washington Co: 4 mi S Midvale, 3200 ft; MONTANA: Beaverhead Co: 1.7 mi E. Bannock Pass Summit.

A. tridentata vaseyana f. *spiciformis*: IDAHO: Camas Co: 13 mi N Fairfield, 7000 ft; Franklin Co: 28 mi NE Preston, 6850 ft.

A. tridentata vaseyana "f. *xericensis*": IDAHO: Washington County: 8 mi N Weiser, 2580 ft (3 males, 7 females paratypes)

A. tridentata wyomingensis: IDAHO: Canyon Co: 15 mi S Nampa, 2500 ft; Elmore Co: 3 mi N Mt. Home, 3325 ft; Gooding Co: 3 mi S Hagerman, 2964 ft; 9 mi W Bliss, 3000 ft (male paratype); 12 mi N Gooding, 4400 ft; Lemhi Co: 1 mi NE Baker, 4500 ft; Lincoln Co: 12 mi W Kimama, 4275 ft; Owyhee Co: .5 mi S Grasmere, 5125 ft; 5 mi N Reynolds; Twin Falls Co: 8 mi N Roseworth, 4800 ft; 4 mi E Twin Falls, 3746 ft (3 males, 6 females, 3 pupae paratypes).

Specimens reared from the species below are indistinguishable from those on *A. tridentata*.

A. arbuscula: IDAHO: Bear Lake Co: 12.4 mi E Montpelier, 6350 ft; Owyhee Co: 14 mi S Riddle, 5300 ft; Twin Falls Co: 8 mi SW Rogerson, 6200 ft.

A. nova: IDAHO: Butte Co: 10 mi E Howe, 5150 ft; 19.9 mi NE Howe, 5100 ft; Cassia Co: 8 mi SE Albion, 5350 ft (specimens reared); 3 mi NW Malta, 4400 ft.

A. cana cana: IDAHO: Custer Co: 10 mi S Stanley, 6550 ft.

A. tripartita: IDAHO: Bannock Co: .5 mi W McCammon, 4719 ft; Lincoln Co: 10.5 mi NE Richfield, 4700 ft; Teton Co: 4.5 mi W Tetonia, 6025 ft (specimen reared).

Rhopalomyia medusirrasa Gagné, new species

(Figs. 40, 90, 91)

Diagnosis

Adults, larvae and pupae of this species are anatomically indistinguishable from *R. medusa*. Both form the same type of gall but that of *R. medusirrasa* is densely covered with long trichomes, whereas that of *R. medusa* is naked.

Adults of *R. medusirrasa* are separated from the related *R. pomum* and *R. calvipomum* on the basis of the trichoid sensilla on the abdominal sterna and the presence or absence of basimeral lobes on the male genitalia.

Description

External anatomy as for *R. medusa*. Male genitalia (Figs. 90-91). Pupal head as in Figs. 67-68.

Holotype, male, 22.5 mi S Hansen, Twin Falls Co., Idaho, V-16-1969, *Artemisia tridentata vaseyana*, R. G. Jones, USNM Type No. 66643.

Biology

Seasonal occurrence. Immature larvae were found during early October 1968 at Sites 5 and 25, coinciding with the first sign of gall development. The only collection made of mature larvae was on May 16, 1969 at Site 6. Adults had emerged prior to May 21, 1969 at Site 4. Under laboratory conditions, adults emerged April 25, 1969 from galls collected on April 22 at Site 13 and on May 19, 1969 from galls collected on May 16 at Site 6 when pupae were present.

Gall

Description and development. This gall (Fig. 40) resembles that of *R. medusa* but differs in that all radiating filaments are densely clothed with long trichomes. These trichomes generally mask the reddish and green colors of the filaments and give the gall a white or gray appearance.

Twenty-four mature galls from Sites 6 and 25 had a diameter (measured perpendicular to stem) ranging from 12-25 mm (avg. 17). Thirty-one galls that were collected April 14, 1969 at Site 6 prior to ephemeral leaf development had a diameter ranging from 6-16 mm (avg. 10) and contained 1-4 larvae (avg. 2).

The first sign of gall development was in early October with the appearance of small clumps of leaflike structures covered with trichomes at the nodes. The galls grow during the fall and again in the spring until about the time pupae are present. At that time ephemeral leaves were just separating in the bud and no new stem growth had occurred. After adult emergence the galls dried but retained their gray appearance and persisted on the plants as for those of R. medusa.

Associated insects

Platygasteridae. Platygaster sp. was found to parasitize the midge.

Chalcidoidea. Torymus aeneoscapus and a species of Pteromalinae emerged from the galls concurrent or within a week of midge emergence in rearing containers.

Host plants and distribution of specimens studied

Artemisia tridentata: IDAHO: Owyhee Co: 6 mi S Grasmere, 5450 ft; Twin Falls Co: 8 mi SW Rogerson, 6200 ft; NEVADA: Washoe Co: 12 mi SW Reno.

A. tridentata vaseyana: IDAHO: Cassia Co: 4 mi W Almo, 6200 ft (2 males, 4 females, 3 pupae, paratypes); 8 mi W Elba, 6350 ft; Oneida Co: 9.5 mi W Malad, 5200 ft; 7 mi E Sheaville, Oregon; Twin Falls Co: 11 mi S Hansen, 4300 ft; 15 mi S Hansen, 4525 ft; 17 mi S Hansen, 4725 ft; 21 mi S Hansen, 5240 ft; 7 males 5 females, 3 pupae, paratypes); 22 mi S Hansen, 5700 ft (holotype male, 5 males, 6 females, 13 pupae, paratypes); 1 mi NW Magic Mt. Ski Area, 6600 ft.

A. tridentata wyomingensis: Twin Falls Co: Lower Rock Creek Canyon (male, female, pupal exuvium, paratypes).

Rhopalomyia hirticaulis Gagné, new species
(Figs. 41, 69, 70, 92, 93)

Diagnosis

This species and R. tumidicaulis are the only ones responsible for stem galls on A. tridentata. Adults and pupae of both species are generally similar, but those of R. hirticaulis are distinguishable by the 1-segmented palip, more setose mouthparts, and ventrally produced pupal pronotum.

Description

Male. Wing length, 2.1-2.3 mm. Eyes contiguous at vertex. Antenna with 14-15 flagellomeres; neck flagellomere III, 0.47-0.57 length node; neck V, 0.50-0.61 length node; neck VII, 0.57-0.64 length node. Fused labella ellipsoid in frontal view, 6-8 setae per labellum. Palpus 1-segmented, elongate-ovoid, with 6-14 setae, these concentrated on apical half. Frontoclypeus with 5-9 setae per side. Anepisternum with 7-18 setae. Claws strong, toothed. Abdomen: tergum III with 12-18 setae per side, V with 14-21, VII with 16-20, and VIII with 23-29, the two last terga each with several scales and their setae contiguous mesally; pleura with several setae on each of segments IV-VIII, segments VII and VIII with scattered scales also; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 21-27 setae in distal group, 24-29 in basal, these continuous across width of sternum. Genitalia (Figs. 92-93): basimere with conspicuous ventral lobe; telomere ovoid, tooth wide, sternum X truncate apically.

Female. Wing length, 1.5-1.7 mm. Antenna with 13-14 flagellomeres; necks flagellomeres III and V, 0.05 length respective nodes; necks indistinct beyond flagellomere V. Other head and thoracic characters as in male. Abdomen: tergum III with 7-9 setae per side, V with 9-11, and VII with 9-13, lateral groups of VII contiguous mesally; pleura I-V naked, VI with 2-3 setae, and VII with 5-6 setae, 0 scales; sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 19-20 setae in distal group, 8-17 in basal, these separated mesally; tergum VII approximately 0.40 length distal half of ovipositor.

Pupa (Figs. 69-70). Antennal horn produced ventrally with an anteroventral projection and a small basal spur. Frons with pair of angular, bilaterally compressed projections. Pronotum long, greatly extended ventrally between antennal horns.

Holotype, male, 11.5 mi W Kimama, Lincoln Co, Idaho, VIII-16-1969, Artemisia tridentata tridentata, R. G. Jones, USNM Type No. 66644.

Seasonal occurrence. Immature larvae were found June 5, 1969 at Site 24, coinciding with first sign of gall development. Adults emerged in the field on July 23, 2969 at Site 23, and at Site 244 sometime prior to August 8, 1969. Adults emerged July 26-27 from galls collected at Site 23 on July 23, 1968. The following year, adults emerged from July 21-31 from galls collected on July 16 and 23 and Site 23 when pupae were present. Some adults emerged on July 12, 1969, from galls still containing pupae on July 16 at Site 24.

Gall

Description. The mature gall is a slight swelling of the vegetative stem and is covered by long white trichomes (Fig. 41). Its sclerenchymatous larval capsules are found between the woody tissues and the outer layers of stem tissue. The galled stem may be slightly bent or, if larvae are near the apex of the gall, it may be stunted.

Forty mature galls from Sites 23 and 24 were measured with the length of the stem surface covered by long trichomes ranging from 4-19 mm (avg. 9). The length of the trichomes ranged from approximately 1 to 2 mm. The galls contained from 1-7 larval chambers (avg. 2).

Developing galls were first observed in early June and found to differ from mature galls only in size. Galls were mature in mid-July when the larvae and pupae were well encapsulated within the stem and normal ephemeral leaves were mature. The old galls persisted on the plant for a year or more.

Effect on the plant. Some of the stems with galls died soon after midge emergence while others maintained their normal functions and produced new growth the next season. Galls were never found sufficiently abundant to cause more than slight damage to plants.

Associated insects

Platygasteridae. Platygaster sp. was found to parasitize this midge species.

Chalcidoidea. Torymus aeneoscapus and an undetermined species of Eupelmidae were reared from these galls.

Host plants and distribution of specimens studied

Artemisia tridentata tridentata: IDAHO: Lindoln Co: 11 mi W Kimama, 4275 ft (holotype male, and 3 males, 4 females, and 4 pupae, paratypes); Minidoka Co: 2 mi E Acequia, 4200 ft (10 pupae, paratypes).

Rhopalomyia tumidicaulis Gagné, new species
(Figs. 42, 71, 72)

Diagnosis

This species and *R. hirticaulis* form the only stem galls known on *A. tridentata*. Both species are generally similar with identical genitalia and strong tarsal claws, but *R. tumidicaulis* pupae have bilaterally compressed and more strongly sclerotized antennal horns, and adults have 2-segmented palpi.

Description

Male. Wing length, 1.9-2.0 mm. Eyes at vertex separated by less than one facet diameter. Antenna with 13-14 flagellomerees; neck flagellomere III approximately 0.5-0.6 length node; neck V, 0.5 length node; neck VII, 0.5-0.6 length node. Fused labella ellipsoid in frontal view, 304 setae per labellum. Palpus 2-segmented, segment I longer # than II, with 0-seta, segment II short ovoid, with 2-3 setae. Frontoclypeus with 1-4 setae per side. Anepisternum with 4-11 setae. Claws strong, toothed. Empodia as long as claws. Abdomen: tergum III with 10-13 setae per side, V with 10-13, VII with 9-16, and VIII with 12-13, the setal groups not contiguous mesally; pleura without sclaes, segment VII with 0-2 setae, VIII with 3-4, sterna II-VII each with basal pair of trichoid sensilla, sternum VII with 13-14 setae in distal group, 20-26 in basal, these continuous across sternum. Genitalia: basimere very wide at base, tapering abruptly, then gradually to narrow apex; telomere ovoid, tooth wide; sternum X truncate.

Female. Wing length, 1.5-1.6 mm. Antenna with 13 flagellomeres, none with distinct necks. Other head and thoracic characters as in male. Abdomen: tergum III with 5012 setae, V with 11-15, and VII with 10-13; pleura naked; sterna II-VII each with basal pair of trichoid sensilla; sternum VII with 21-23 setae in distal group, 10-13 in basal; tergum VII 0.35-0.37 times length distal half of ovipositor.

Pupa (Figs. 71-72). Antennal horn short, strongly sclerotized ventrally and bilaterally compressed. Frons with pair of projections laterad of base of clypeus. Pronotum long, projecting slightly ventrad.

Holotype, male, 15 mi S Nampa, Canyon Co., Idaho, IX-4-1968, *Artemisia tridentata wyomingensis*, R. G. Jones, USNM Type No. 66645.

Biology

Seasonal occurrence. Adults emerged September 19-25, 1968 from galls collected on September 4 with pupae present.

Gall

Description. This polythalamous gall (Fig. 42) reaches maturity in the early fall just prior to bloom. It forms a swelling on a vegetative stem that becomes stunted, has numerous nodes and has small malformed leaves. Interspersed among the wood fibers of the inner stem are the sclerenchymatous larval capsules.

The length of nine of these stunted stems ranged from 5-23 mm (avg. 15). Three galls contained six, seven and eight larval capsules respectively.

Associated insects

Platygasteridae. *Platygaster* sp. was reared from these galls.

Chalcidoidea. *Tetrastichus* sp. and an undetermined species of Pteromalinae were reared from these galls.

Host plants and distribution of specimens studied

Artemisia tridentata wyomingensis: IDAHO: Canyon Co: 15 mi S Nampa, 2500 ft (holotype and 4 males, 10 females, and 1 pupa, paratypes).

APPENDIX

Other Nearctic Species of *Rhopalomyia* *(Diarthronomyia)*

by R. J. Gagné

All the described species of North American *Diarthronomyia* that occur on plants other than *Artemisia tridentata* or not in Idaho are listed below. Nine such species are known and they occur on other *Artemisia* species and cultivated *Chrysanthemum* spp. A diagnosis of the gall midges and galls and type information is given for each. The scientific names of Nearctic *Artemisia* hosts are given as originally cited (with any misspellings and without author names) at the time of the insect descriptions because it is impossible now to know if the identifications were accurate.

Rhopalomyia alticola Cockerell

Rhopalomyia alticola Cockerell 1980-281.

Diagnosis

Only a gall remains of the type series in the USNM. Cockerell subsequently collected more adults which were described by Felt (1915b). These are medium-sized with a wing length of 2.0 mm in the male, 1.6 mm in the female, have 1-segmented palpi, simple claws, a pair of basal trichoid sensilla on each of abdominal sterna II-VII, and numerous setae on the abdomen. The telomeres of the male genitalia are short-ovoid and the apical teeth appear narrow. *Rhopalomyia alticola* differs from all other Nearctic *Diarthronomyia* in that the empodia are noticeably longer than claws.

Types. Male, female, pupa, larva, and gall, West Cliff, Colorado, emerged IV-24 (and earlier) 1890 from ? *Artemisia canadensis*, T. D. A. Cockerell; gall in USNM, other type specimens unaccounted for. Other specimens examined: 2 males, 2 females, Boulder, Colorado, (emerged) I-1907, *A. canadensis*, T. D. A. Cockerell.

Gall

The gall is a spherical mass of long trichomes, about 15 mm in diameter. It consists of an aggregate of several capsules each of which encloses a larva. From the figure in Felt (1940), the gall appears to be either a node or bud gall.

In the original description (Cockerell, 1890), the host of *R. alticola* was given as "a composite . . . a *Chrysopsis* or *Solidago*." Cockerell (1909) subsequently recorded the host as "*Artemisia canadensis*." Felt (1917) later listed "*Artemisia forwoodii* (? *canadensis*)" and, questionably, *A. caudata*" as hosts. Baker (1895) reported a similar gall on "*A. dracunculoides*."

Rhopalomyia betheliana Cockerell

Rhopalomyia betheliana Cockerell 1909:150.

Diagnosis

Wing length is 1.7-1.8 mm in the male, 1.3-1.4 mm in the female. The palpi are 1-segmented, the claws simple, trichoid sensilla are present on the abdominal sterna, and setae on the mouthparts and abdomen are scarce. The pupa resembles that of *R. lignea* with its very elongate antennal horns, but the pronotal setae of *R. betheliana* are approximately as long as the horns.

Gall

This is monothalamous, pyriform, approximately 34 mm long by 2 mm in basal diameter. It is covered with trichomes and occurs on the flower buds (cf. Fig. 335, Felt 1940).

Types. Lectotype male, here designated, Denver, Colorado, emerged III-1909, "*Artemisia frigida*", in USNM. Paralectotypes, 6 males, 7 females, and 5 pupal exuvia, all with same data as lectotype.

Rhopalomyia chrysanthemi (Ahlberg)

Diarthronomyia hypogaea: Felt 1915a:267 (not F. Loew 1885)
Diarthronomyia chrysanthemi Ahlberg 1939:276

Diagnosis

Wing length is 1.6-1.9 mm in the male, 1.4-1.7 in the female. The palpi are 2-segmented and the claws toothed. The basimere of the male genitalia has a ventral lobe and the elongate-ovoid telomere tapers gradually from midlength to the wide, apical tooth. The pupal antennal horns resemble those of *R. obovata* or *R. nucula* except that they are more pointed and the frontal ridges basad of the horns are not present in *R. chrysanthemi*.

Types. Lectotype male, here designated, labelled "E. Lansing, Mich., R. H. Pettit, 12611". It presumably was reared from commercial chrysanthemums from Adrian, Michigan (Felt, 1915a). Paralectotypes, 8 males, 9 females, 2 pupae, same data as lectotype. Ahlberg (1939) provided a name for the species misidentified by Felt (1915a) as *Rhopalomyia hypogaea* but designated no types and gave no specific data for specimens in his own collection. It seems proper, therefore, to use a specimen from Felt's series referred to in Ahlberg (1939).

Gall

This is a small, monothalamous, and conical gall occurring on the leaves, young stems, sepals, and buds of commercially grown chrysanthemums. It is not known from wild chrysanthemums and its geographical origin is conjectural. It was, at one time, almost cosmopolitan (Barnes 1948, q.v. for complete historical and economic review of this species). This gall was first identified as *Rhopalomyia hypogaea* (Loew) by Felt (1915a), who assumed it had been introduced to North America on commercial plant stock from Europe. After the misidentification was corrected (Ahlberg 1939), Barnes (1939) suggested that R. chrysanthemi had been introduced into England and Europe separately from America because of the fact it was first noticed here in 1901 (Essig 1916). But perhaps the species originated in the eastern Palearctic Region. Monzen (1937) described the Japanese R. chrysanthemum from galls on Chrysanthemum morifolium Hemsl. that are similar to those of R. chrysanthemi. That plant is a native Asian species from which many horticultural varieties have been developed. Yukawa (1971) has suggested that R. chrysanthemum and R. chrysanthemi are synonymous.

Rhopalomyia clinata Gagné

Diarthronomyia californica Felt 1912:752, Junior secondary homonyn of
Rhopalomyia californica Felt 1908.
Rhopalomyia clinata Gagné 1975:483, new name for californica (Felt 1912a)

Diagnosis

This is a tiny species with a wing length of 1.5-1.6 mm in the male, 1.1-1.2 mm in the female. It has 1-segmented palpi, toothed claws, trichoid sensilla on the abdominal sterna, and males have a ventral lobe on the short basimere. The adults could pass for those of R. occidentalis, but the pupa of R. clinata is similar to that of R. cramboides with its short antennal horns and frontal projections.

Types. Lectotype, male, here designated, Claremont, Los Angeles Co., California, C. F. Stahl, emerged III-12-1912, "Artemisia californica", C a2269, USNM Type No. 29261. Paralectotypes, 4 males, 3 females, and galls in USNM, and male, 3 females, and galls in Felt Collection, all with same data as lectotype.

Gall

This is small, brown, monothalamous, subconical, thin walled, naked, and protrudes at an oblique angle from the surface of the leaf. The gall is figured in Felt (1940).

Rhopalomyia coloradella Cockerell

Rhopalomyia coloradella Cockerell 1904:155.

Diagnosis

Only a male remains of the type series in the USNM. It has a wing length of 1.61 mm, the palpus is 1-segmented, the claws are simple, the abdominal sterna each have a pair of basal trichoid sensilla, the basimere appears to have a mesoventral lobe, and the telomere is short-ovoid with a narrow tooth. With this combination of characters, the specimen does not fit any of the bud gall makers on A. tridentata.

Types. Lectotype, male, here designated, Colorado Springs, Colorado, Artemisia sp., USNM Type No. 8250. Other specimens, at least one each of female, pupa, larva, and gall, and possibly another male, all with same data as lectotype, probably lost.

Gall

Cockerell (1904) described it as a deformed flower head, about 10 mm long by 5.6 mm broad and covered by the greatly enlarged involucral bracts, which are outwardly smooth, reddish to yellowish, and inwardly covered with white trichomes. The host was given only as "*Artemisia* sp." Inasmuch as *Rhopalomyia* spp. appear to have narrow host preferences, future identification of *R. coloradella* should be difficult.

Rhopalomyia floccosa (Felt)

Diarthronomyia floccosa Felt 1916b:195.

Diagnosis

The females have a wing length of 1.2-1.3 mm, 1 segmented palpi, toothed claws, and sparse abdominal setae. Males are unknown.

Types. Syntypes, 2 females, from galls on "*Artemisia californica*" found on ridge between Mill Valley and Muir Woods, Marin Co., California, emerged XI-20 to 28, 1912, P. H. Timberlake. Type galls are probably lost. Other specimens examined: galls, Santa Barbara, California, Felt Collection C1628.

Gall

This is large and woolly. It is figured in Felt (1940), and is known from Marin and Santa Barbara Counties, California.

Rhopalomyia gnaphalodis Felt

Rhopalomyia gnaphalodis Felt 1911:484.

Diagnosis

Females have a wing length of 1.7-1.8 mm, have 2-segmented palpi, toothed claws, 16-17 antennal flagellomeres, and basal trichoid sensilla on the abdominal sterna. Males are unknown.

Types. Lectotype, female, here designated, Boulder, Colorado, emerged IV-25 to 29-1910 from "*Artemisia heterophylla*', P.H. TImberlake, C 1633, in Felt Collection. Paralectotypes, 2 males, 3 females, leaf with galls, same data as lectotype; galls on buds of "*A. heterophylla*", Puente Hills, near Whittier, Los Angeles Co., California, presumed lost; leaf with galls from "*A. tridentata*", Salt Lake City, Utah, V-1915, in USNM (these probably are made by *R. hirtibulla*).

Gall

This is a tiny, monothalamous, cylindrical, oblique leaf gall. Felt (1916b) lumped together under this species galls from "*Artemisia heterophylla*" and "*A. tridentata*", from California and Utah, respectively, presumably because of superficial similarity. The described adults, however, were from leaf galls on "*A*. *heterophylla*."

Rhopalomyia subhumilis Gagné

Rhopalomyia subhumilis Gagné 1977:426.

Diagnosis

This species has a 2-segmented palpus, toothed claws, a ventral-lobed male basimere, a short, wide-toothed telomere, and pupal frontal projections and well-developed antennal horns. The pupal head will readily distinguish *R*. *subhumilis* from other *Diarthronomyia* with 2-segmented palpi and toothed claws.

Types. Holotype male, nr. Ephraim, Sanpete Co., Utah, in USNM. Paralectotypes, same data, in USNM, Brigham Young University, and California Academy of Sciences.

Gall

The gall is a polythalamous nodule on underground parts of the herbaceous *Artemisia ludoviciana* (Nuttall.). Ranasinghe (1978) reported on the bionomics of *R*. *subhumilis* in Utah.

Rhopalomyia tridentatae Rübsaamen

Rhopalomyia tridentatae Rübsaamen 1893:163.

Diagnosis

Wing length of the male is 2.1 mm, of the female, 1.6 mm. This is the only sagebrush gall midge in North America with the combination of 2-seghmented palpi and simple claws. The male basimere has a mesoventral lobe and the telomere is ovoid with a wide, apical tooth.

Types. Lectotype, male, here designated, North American, from "*Artemisia tridentata*", in Rübsaamen Collection, Zoologisches Museum, Berlin (that collection currently on loan to Staatliches Museum für Naturkunde, Stuttgart, West Germany). Paralectotype, female, same data as male.

The type locality was originally and subsequently listed only as "North America" and, although the type specimens bear no further locality data, the locality can possibly be narrowed to California. The adults specimens were sent to Rübsaamen by Dietrich von Schlechtendahl, an entomologist at the University of Halle in Germany. Essig (1931), in his *History of Entomology*, mentions Schlechtendahl only in the biography of H. H. Behr (1818-1904) in the list of the latter's scientific friends. It is possible that Behr sent the specimens to Schlechtendahl, an old friend and colleague in Halle. Behr came to California in 1851 and, except for a brief visit to Germany, never left the state (Essig 1931). An indication that a gall similar to one attributed to *R*. *tridentatae* does occur in California is Felt's (1915b) statement that there was a gall from California in the Museum of Comparative Zoology in Cambridge that might be attributable to this species. RJG has been unable to locate this specimen.

Gall

Rübsaamen (1893) stated that the adults were reared from a gall on "*Artemisia tridentata*" similar to that formed by the European *R. artemisiae* (Bouché) on "*Artemisia campestris*", viz. a pea-sized, ovoid, bud-like flower gall (Fig. 1303, Vol. 2, Houard 1909). No gall fitting that description was found in Idaho during the course of this study.

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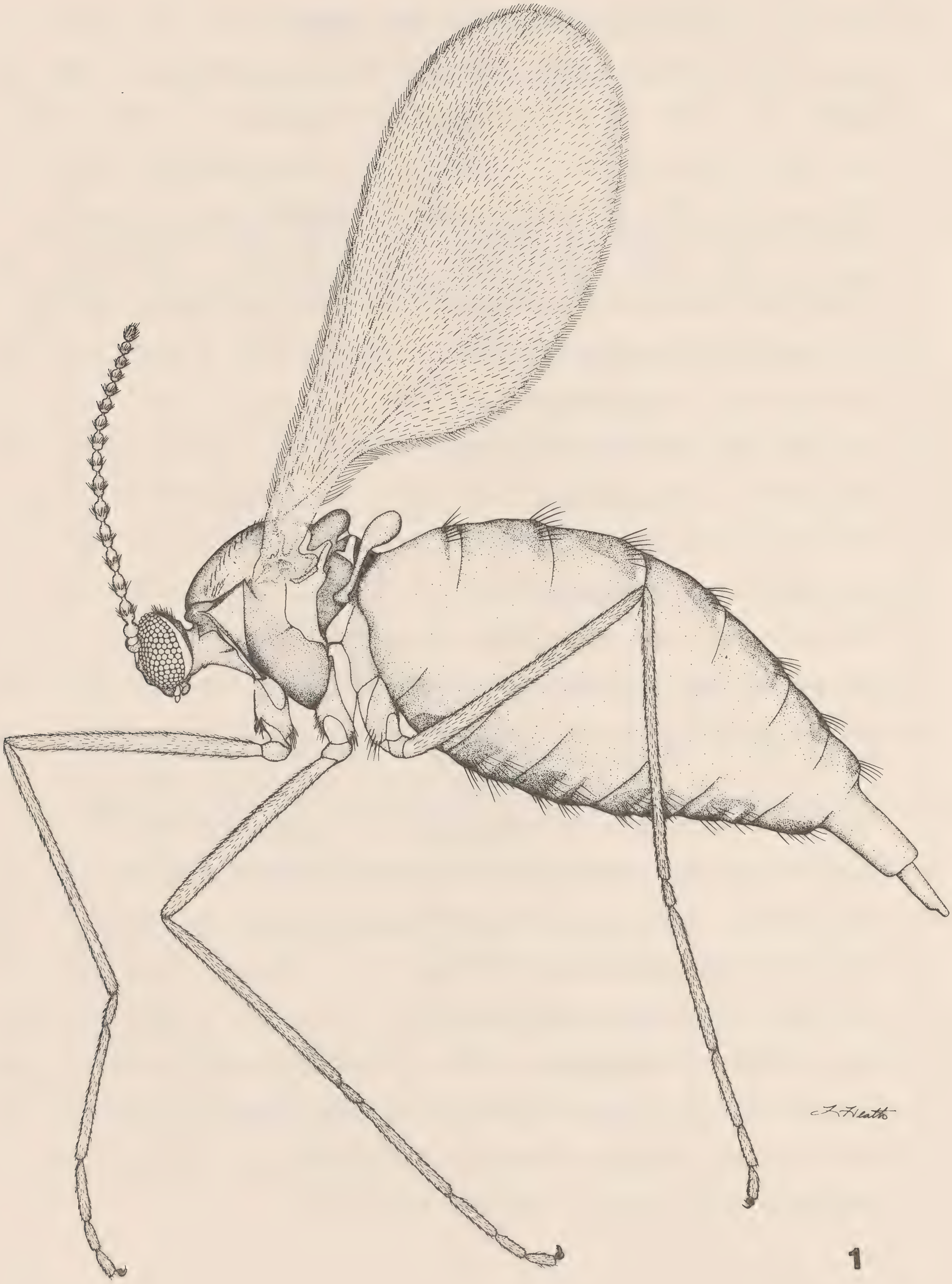

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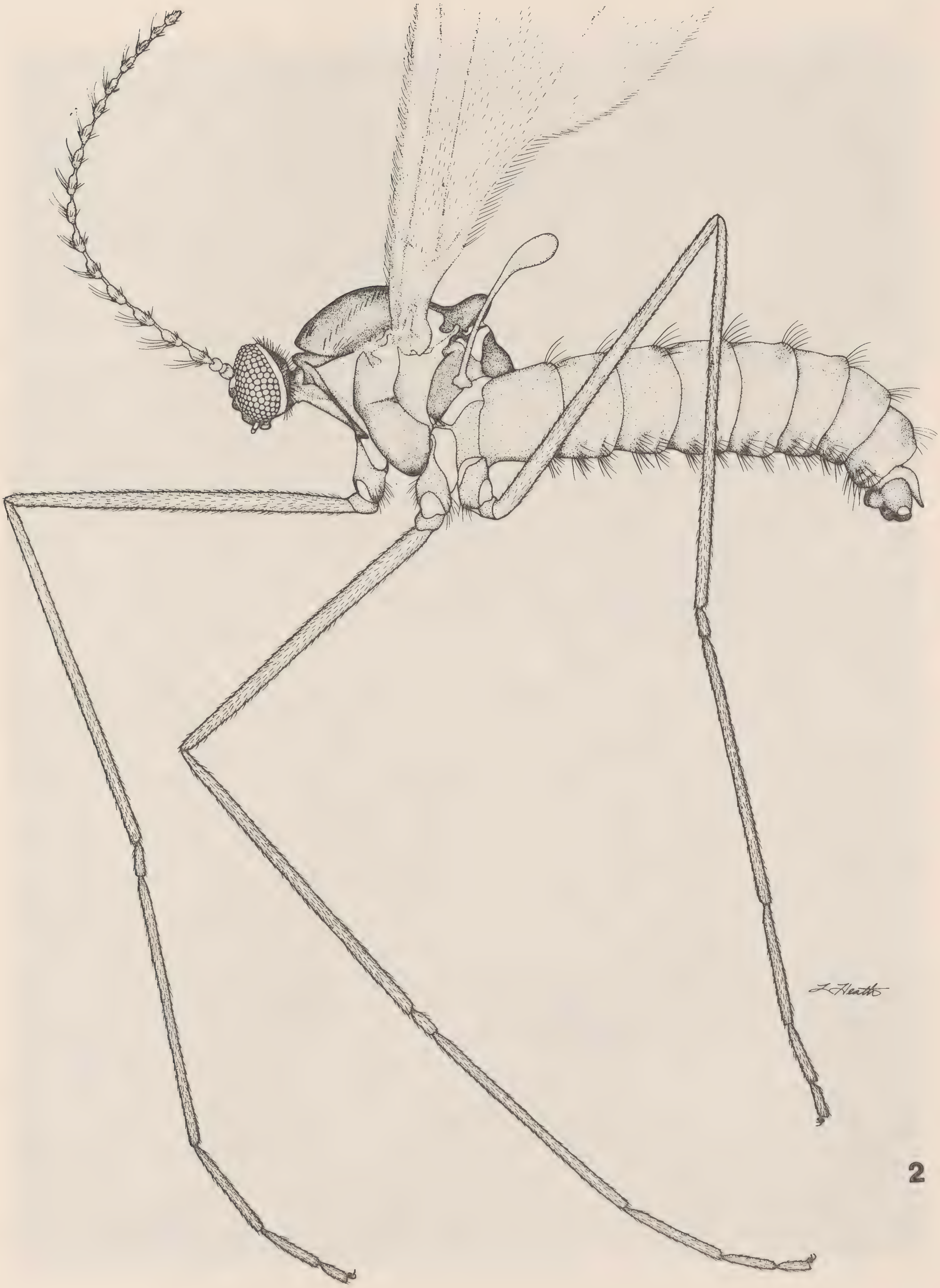

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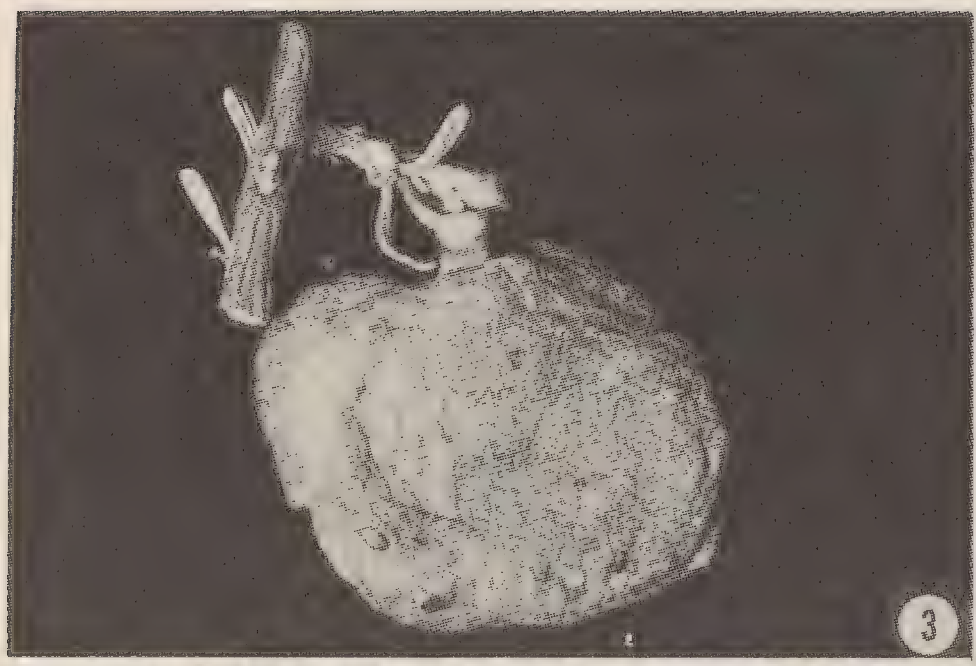
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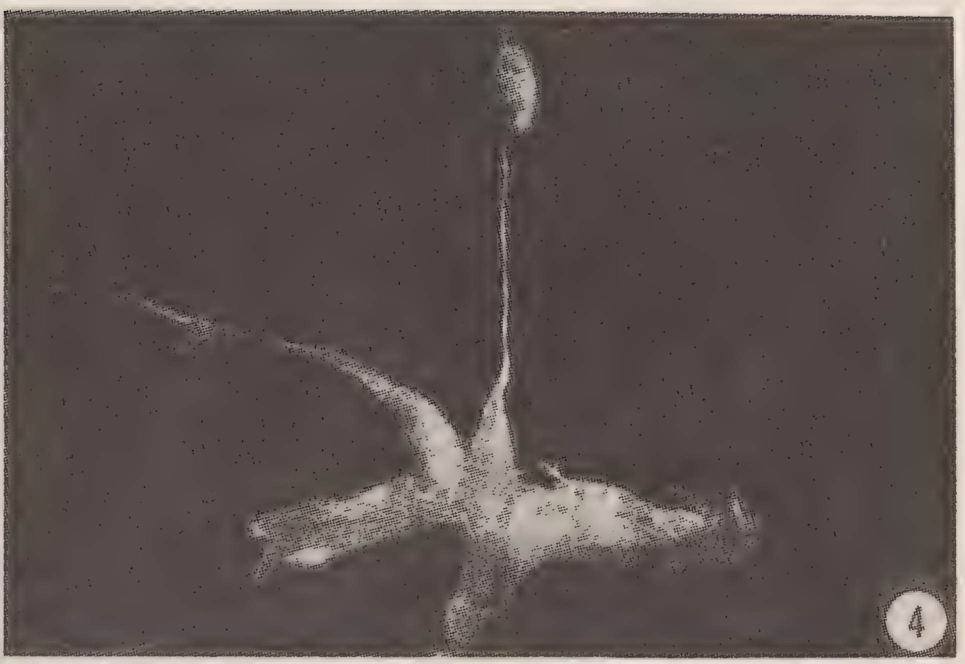
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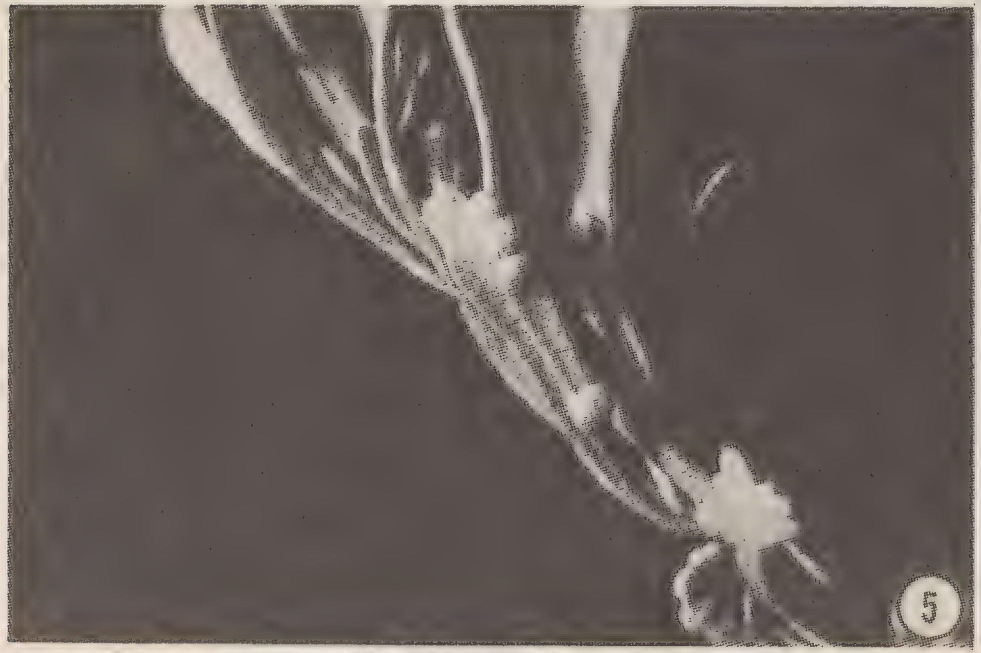
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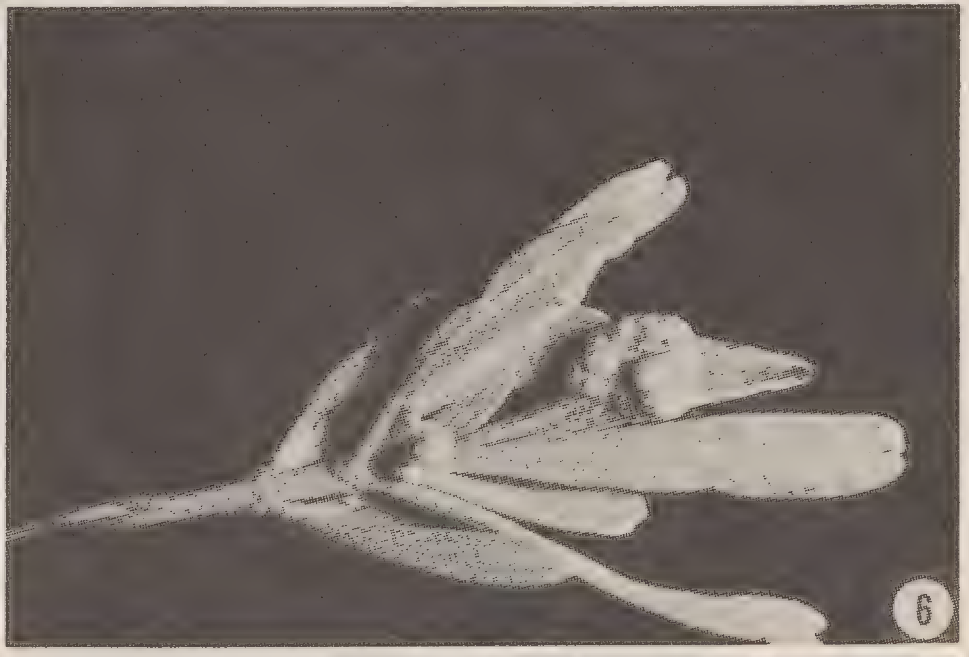
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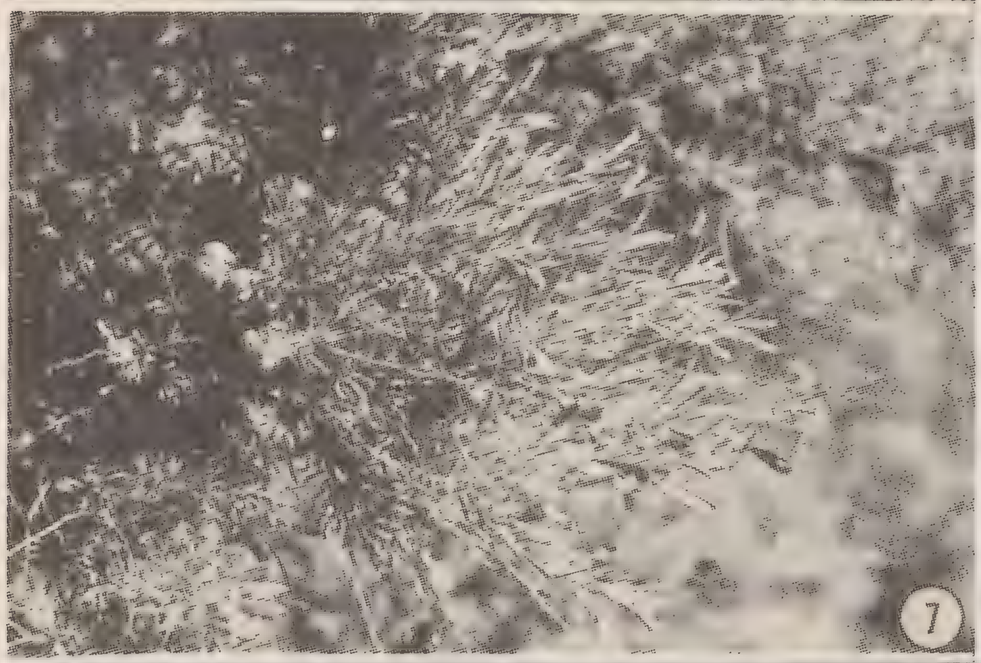
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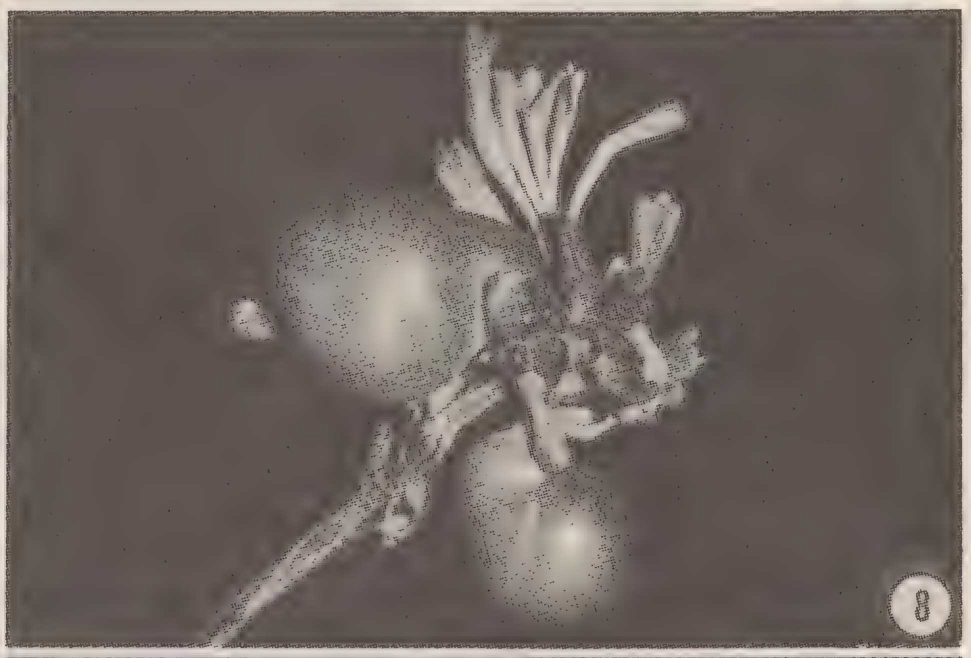
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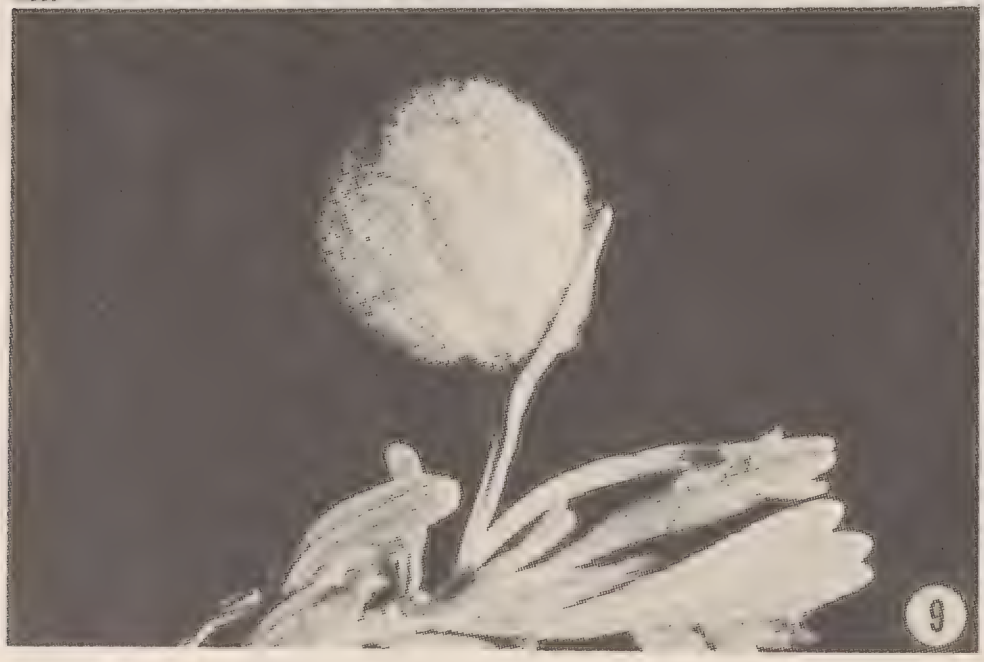
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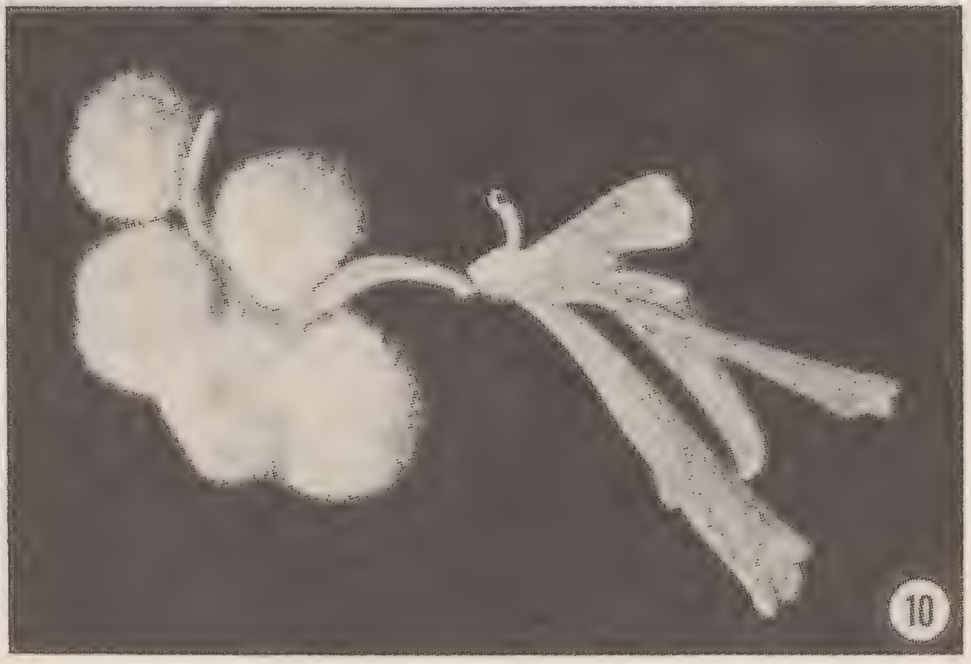
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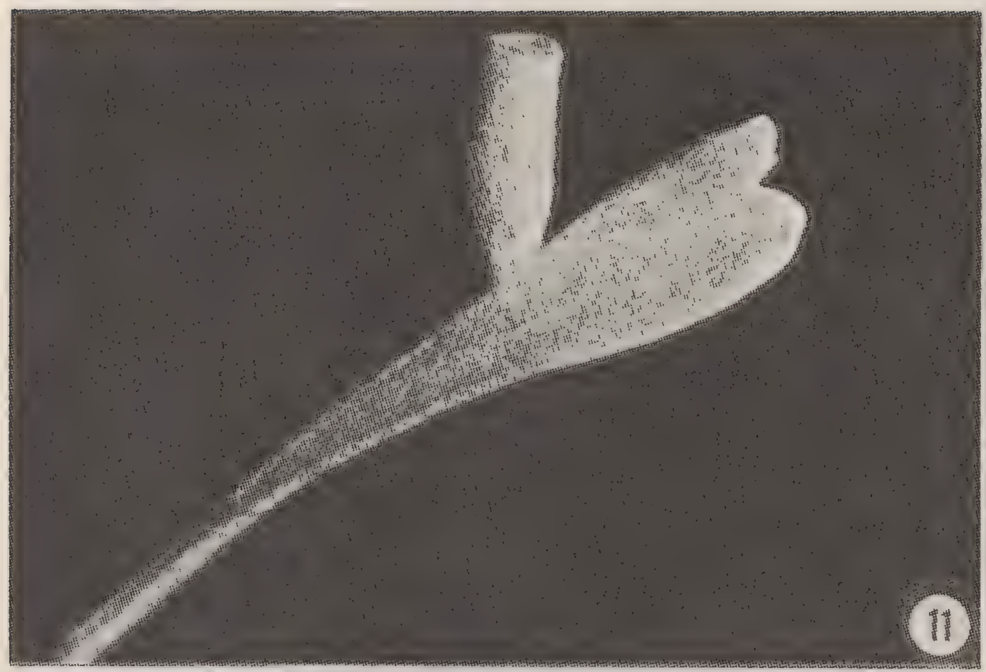
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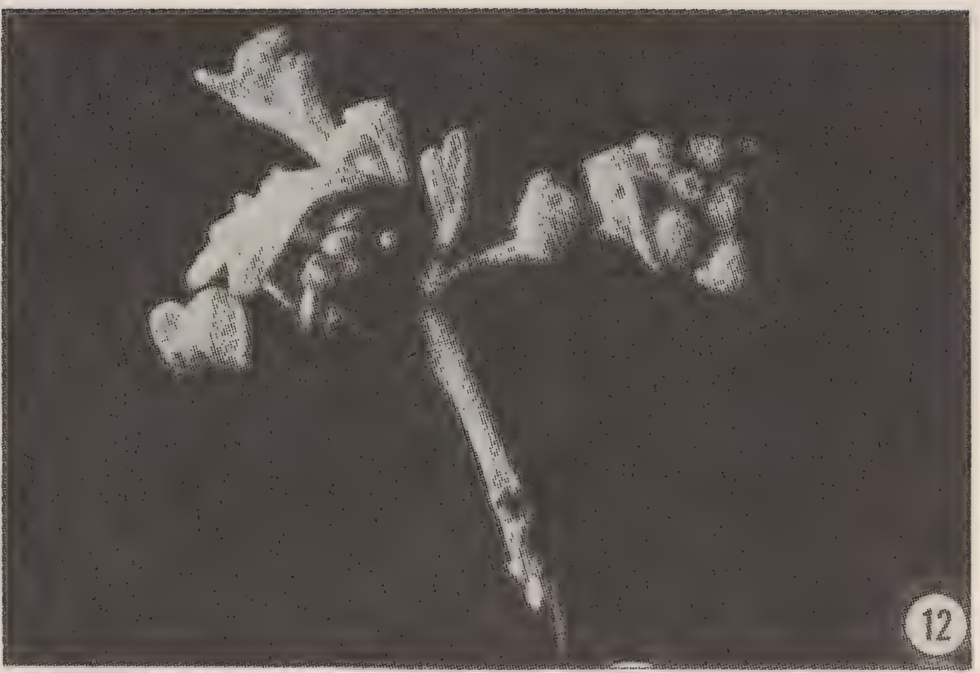
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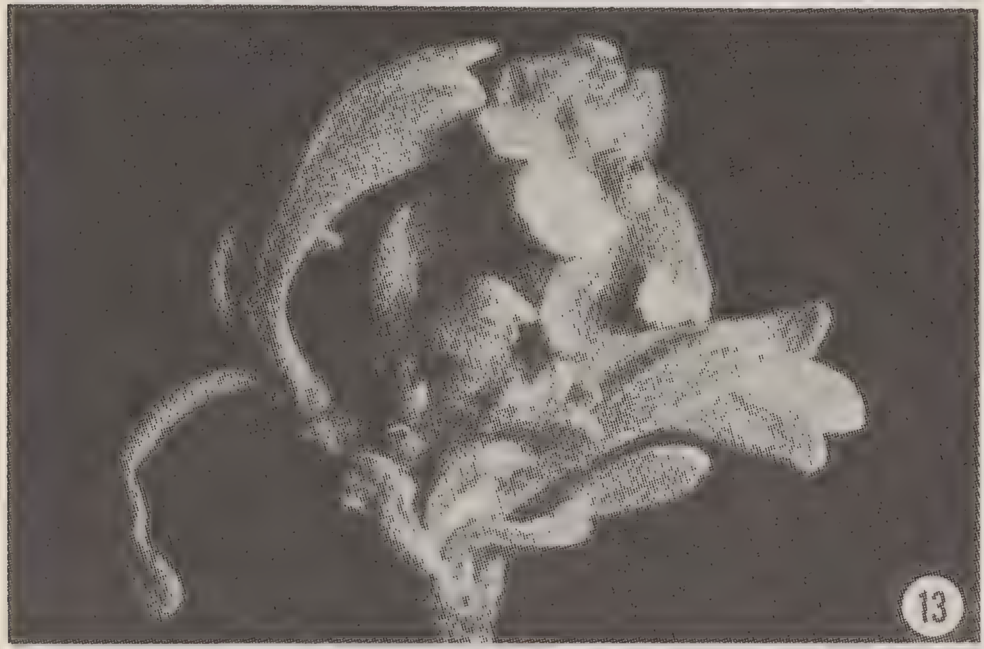
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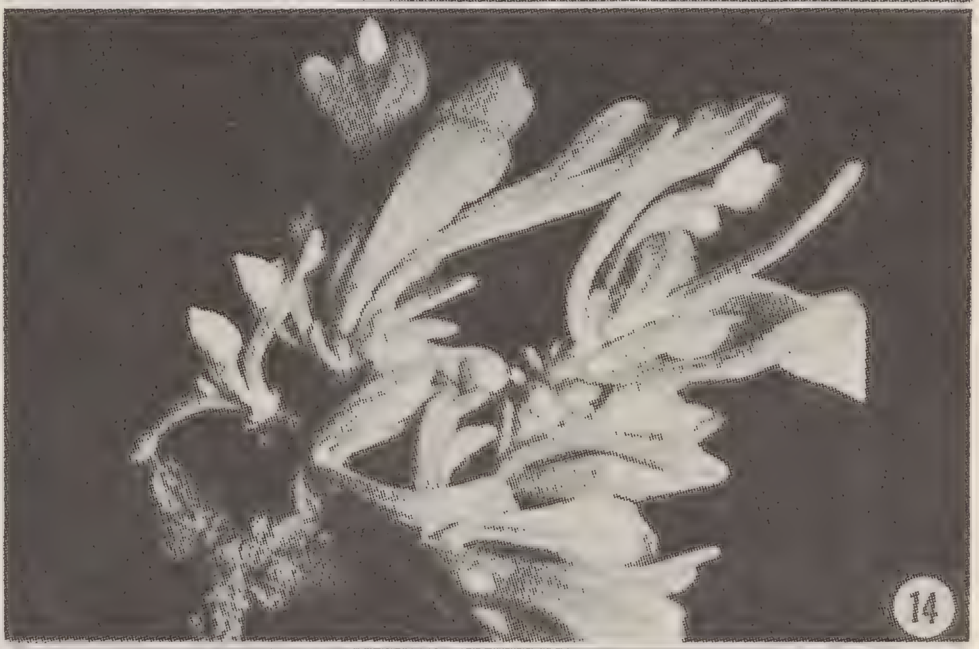
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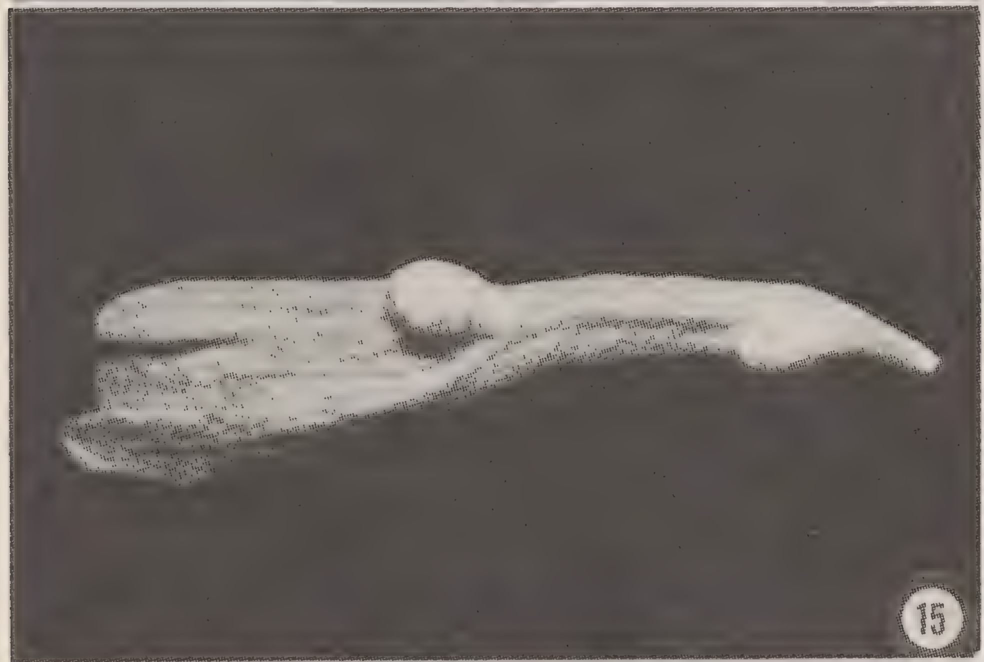
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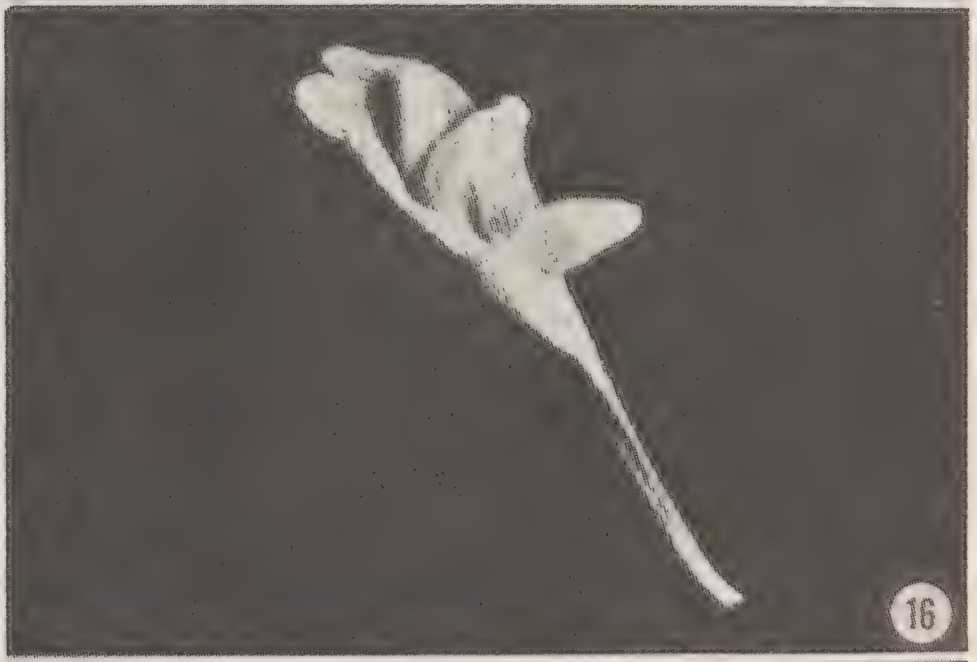
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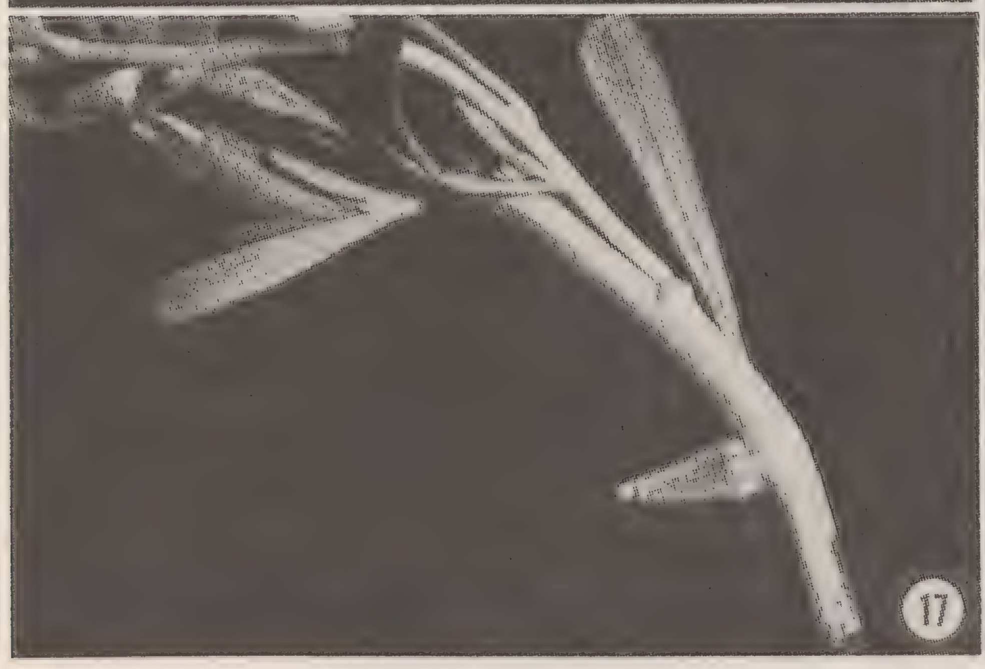
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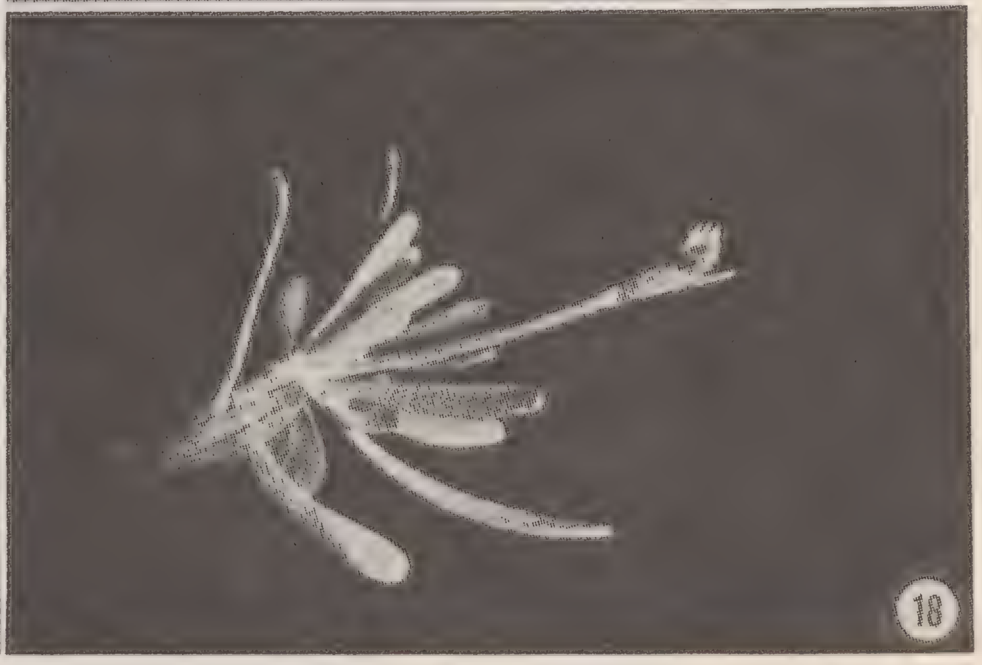
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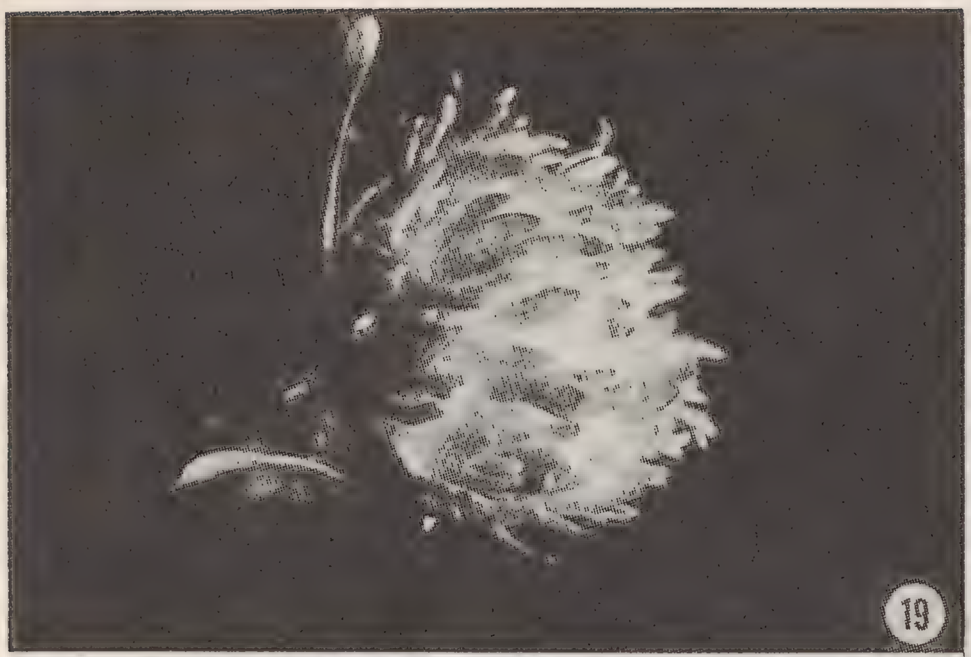
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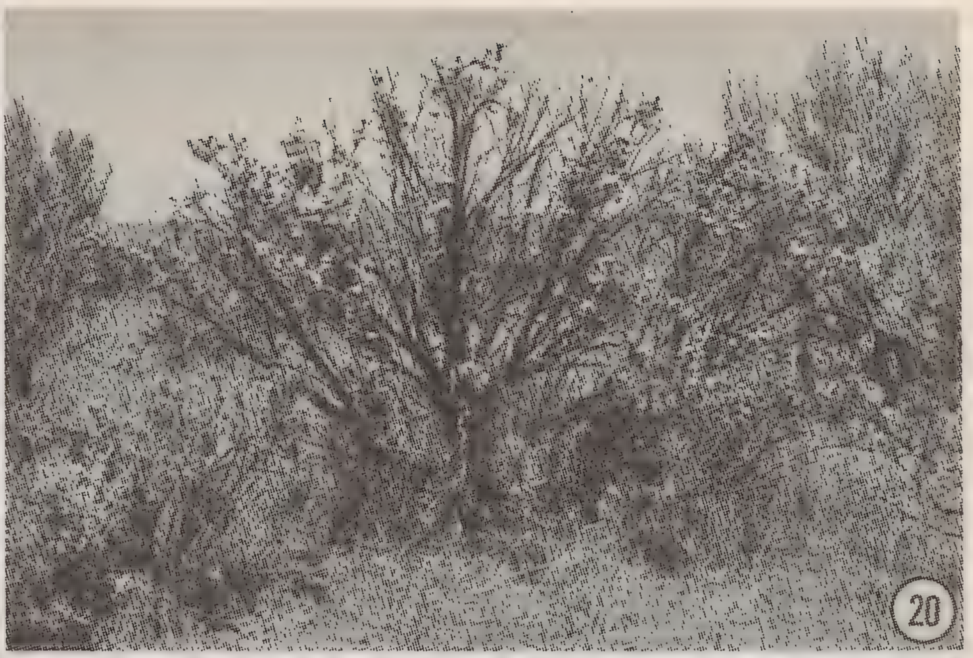
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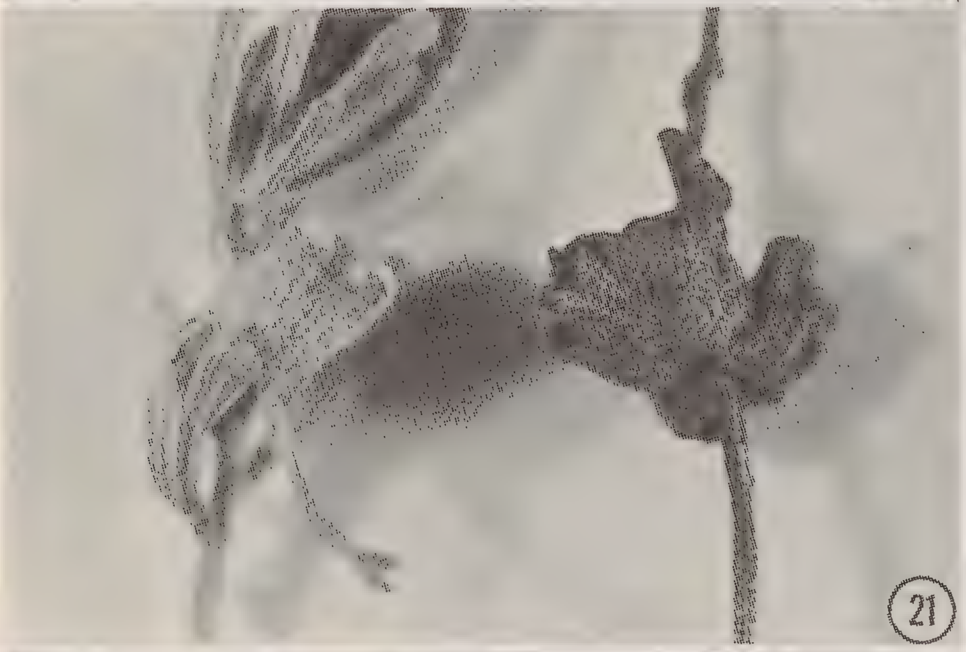
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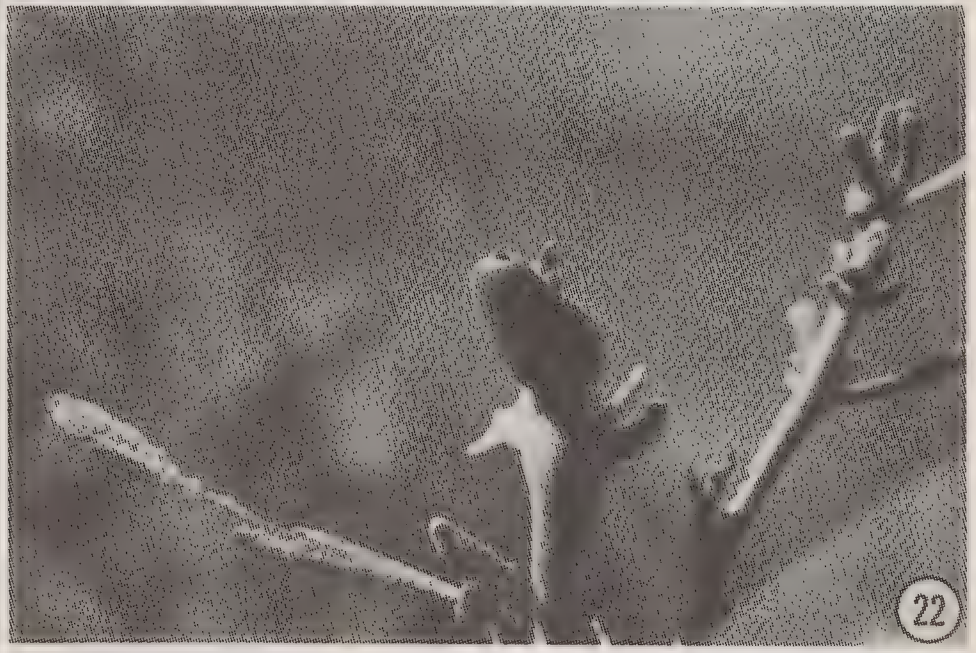
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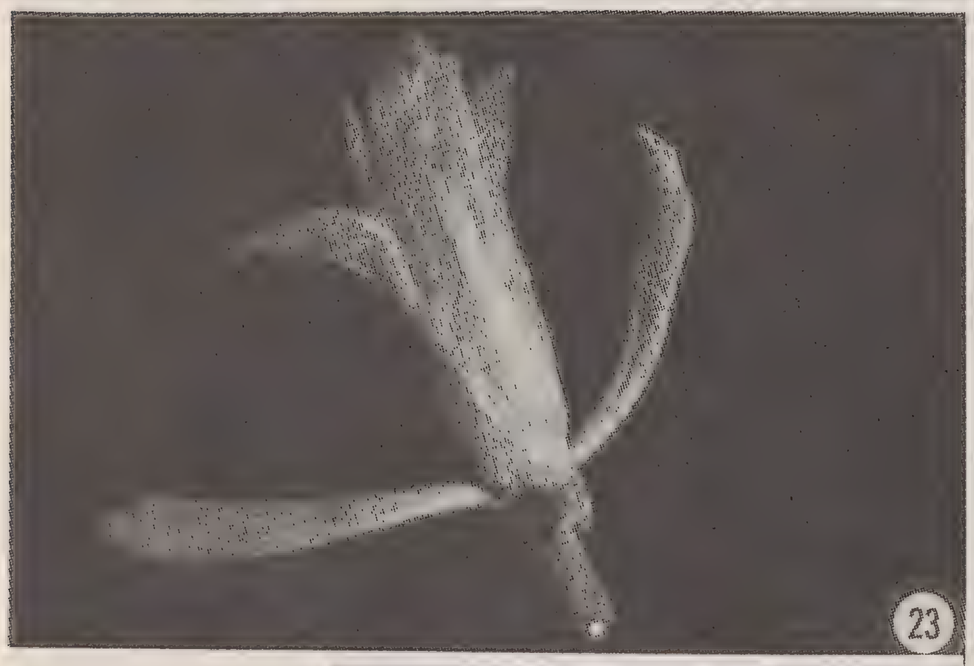
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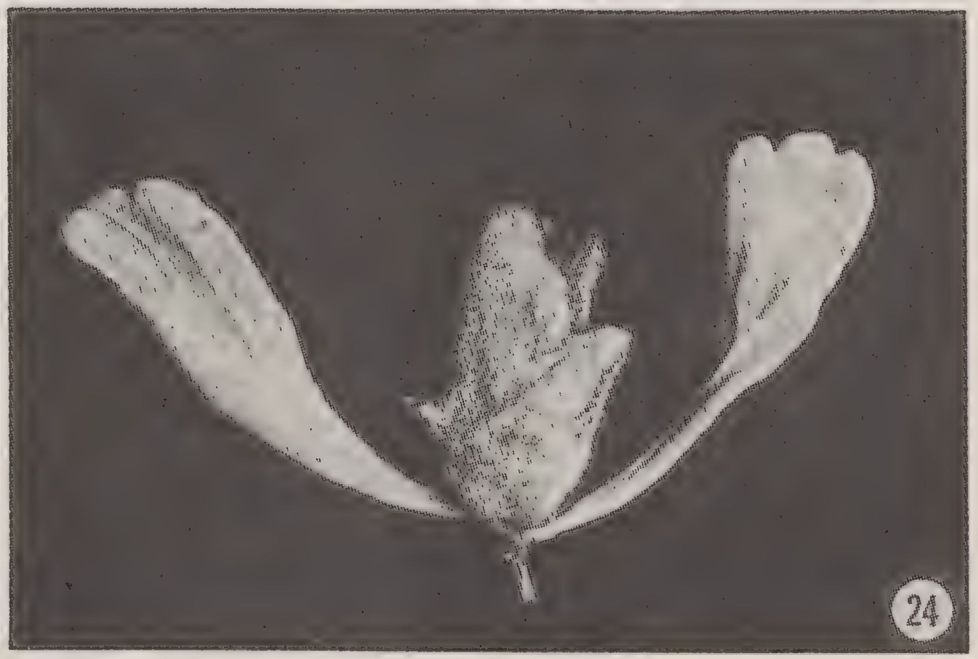
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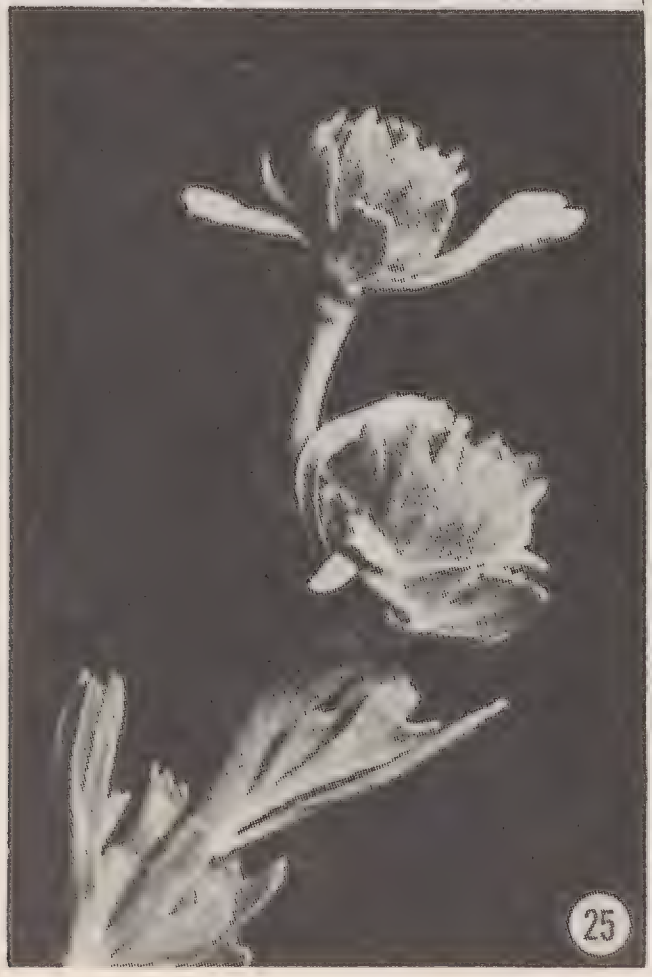
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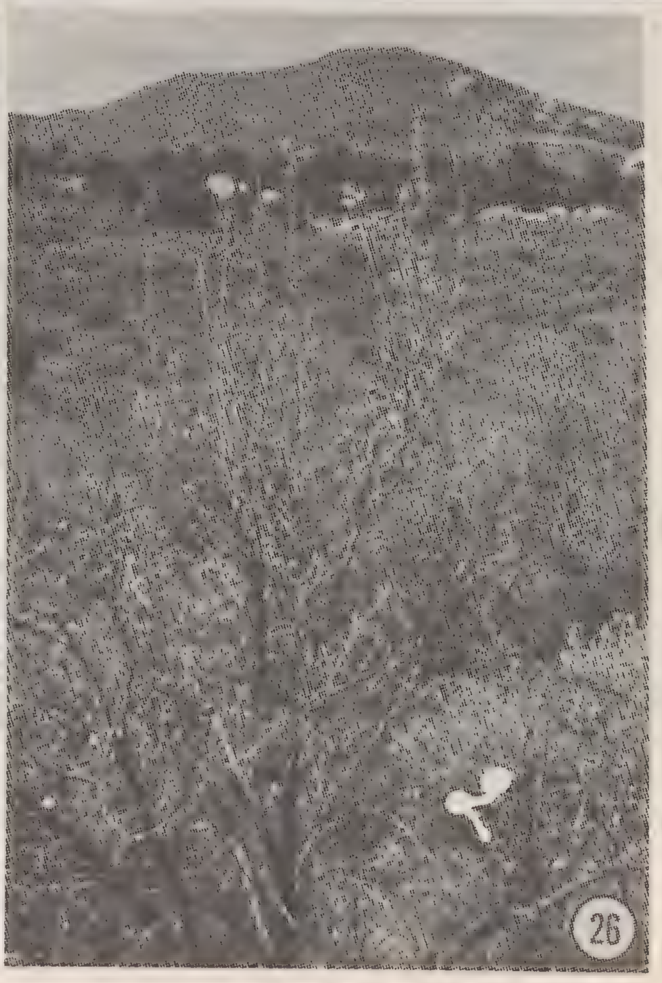
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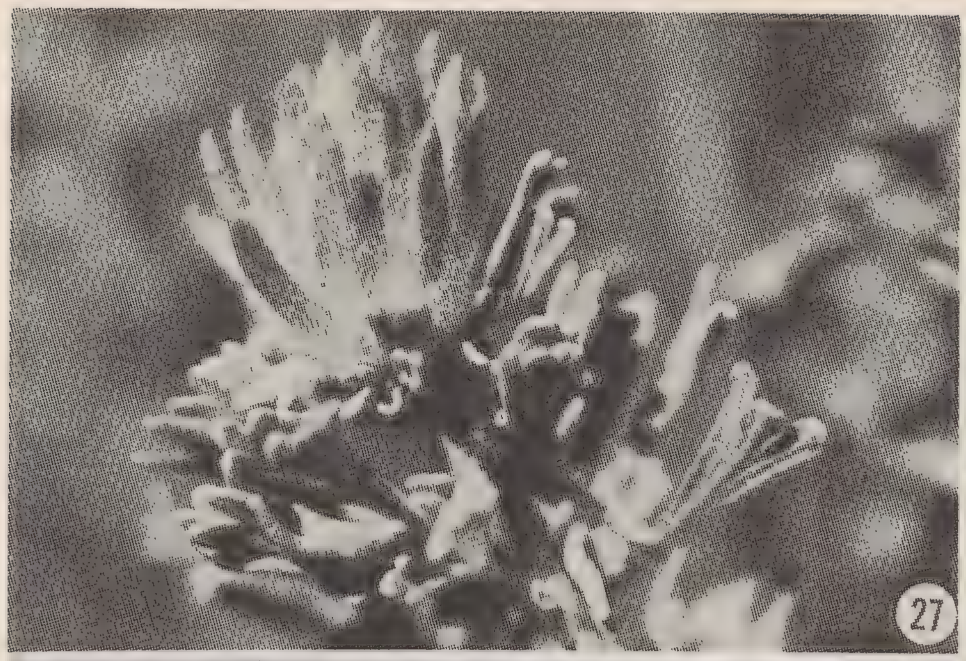
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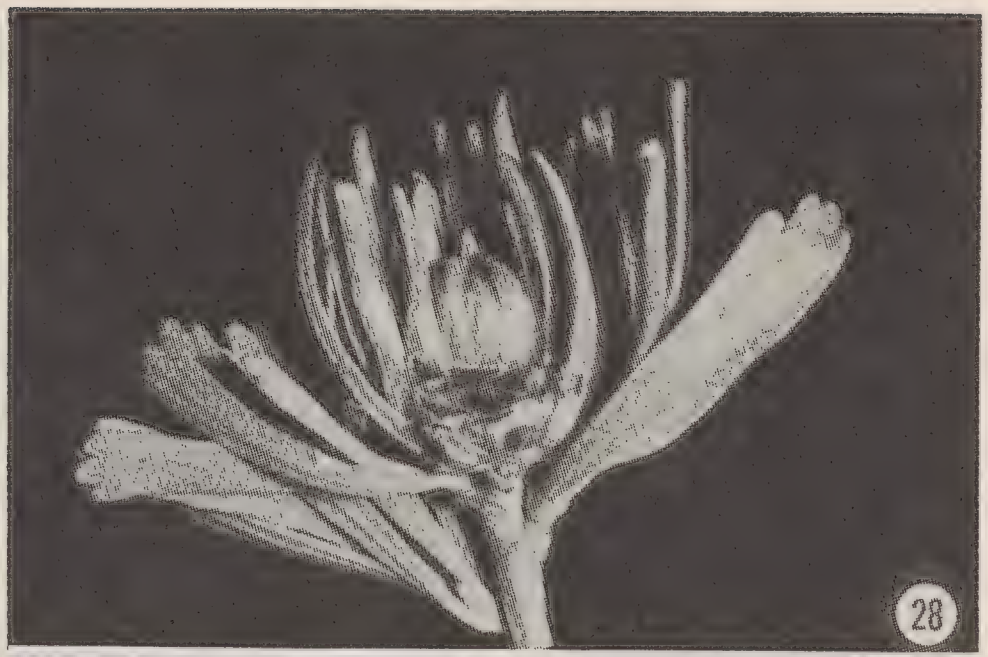
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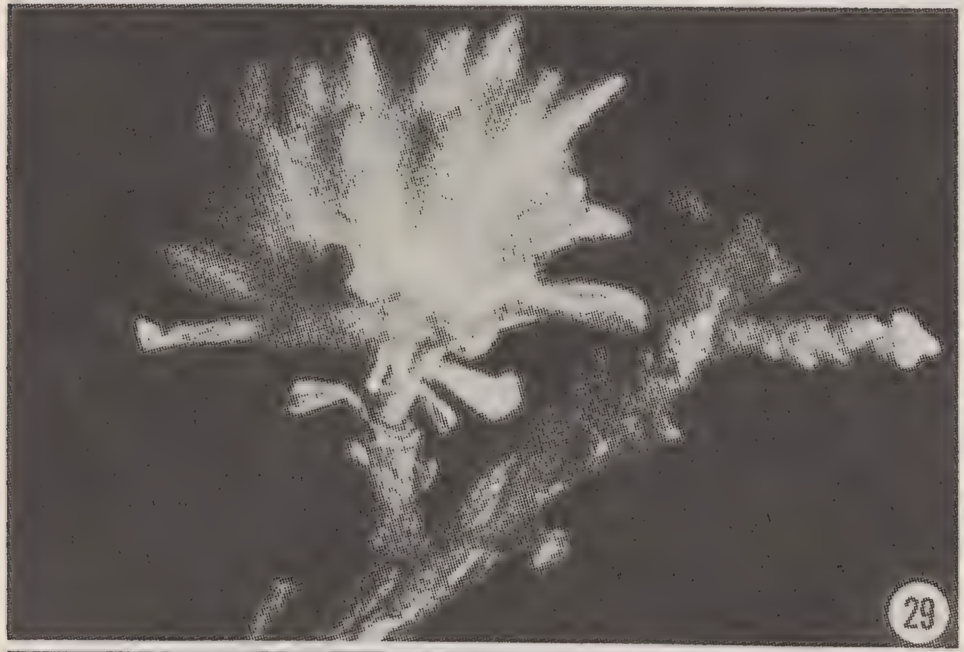
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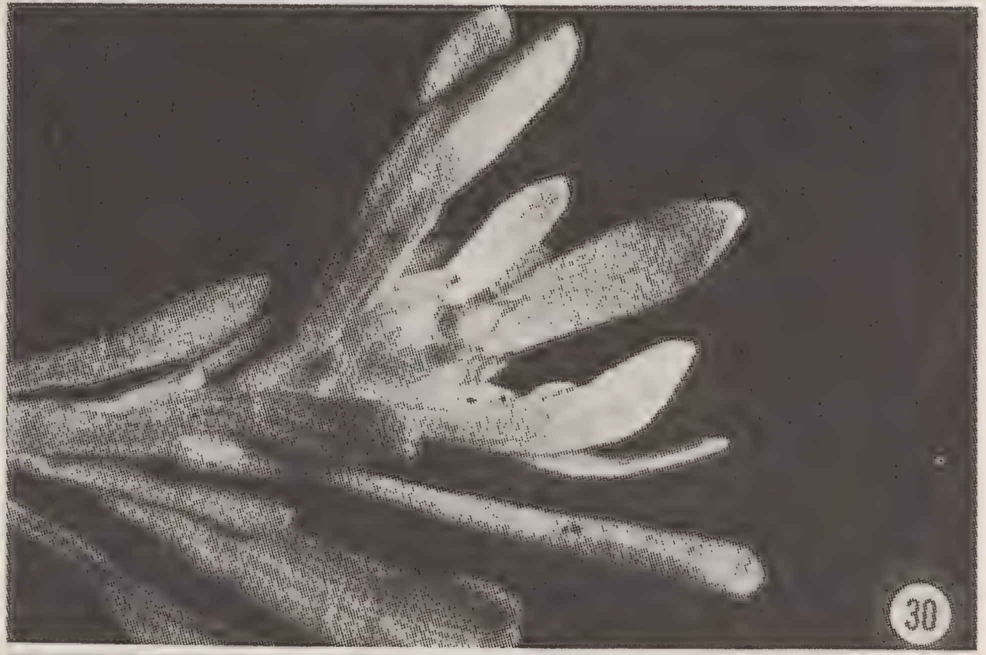
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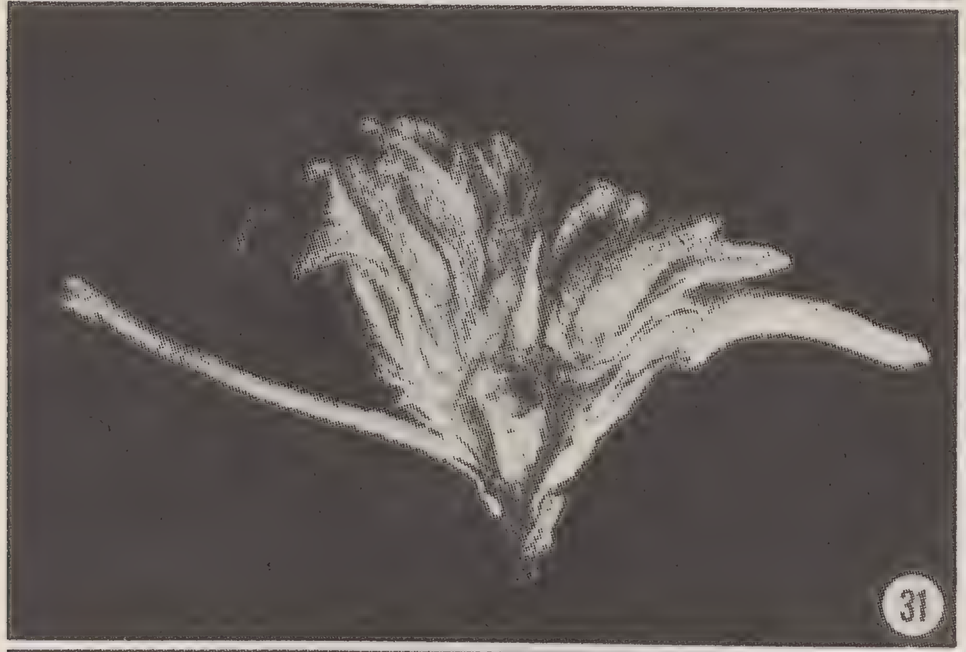
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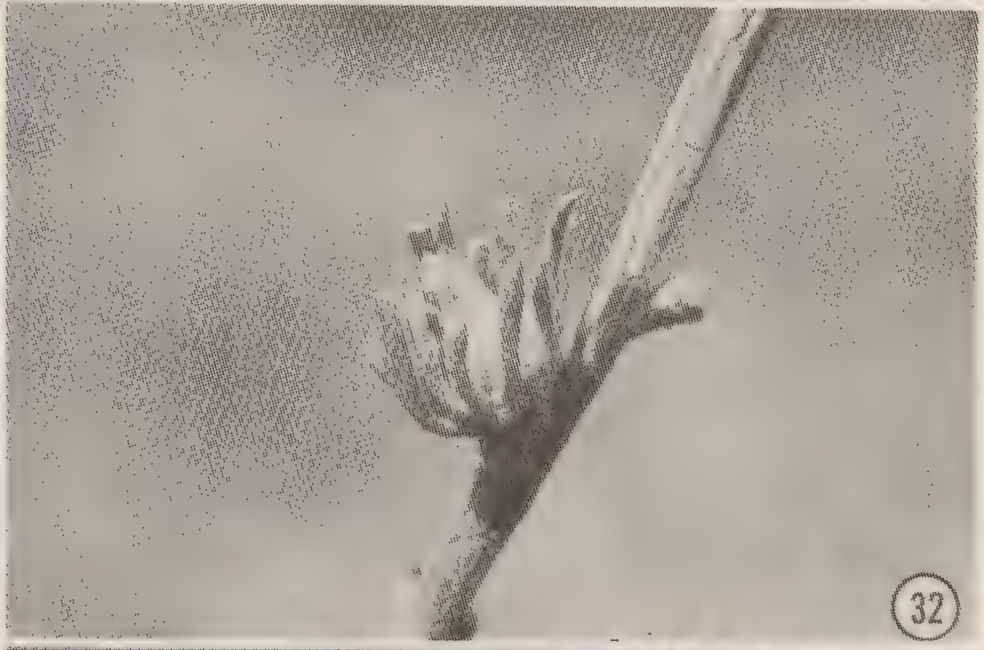
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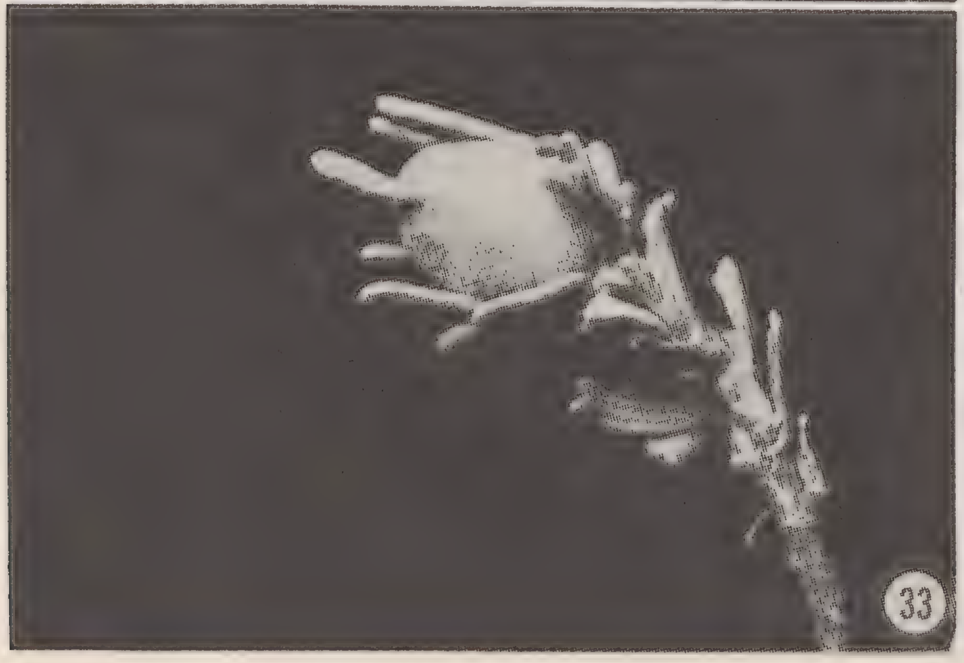
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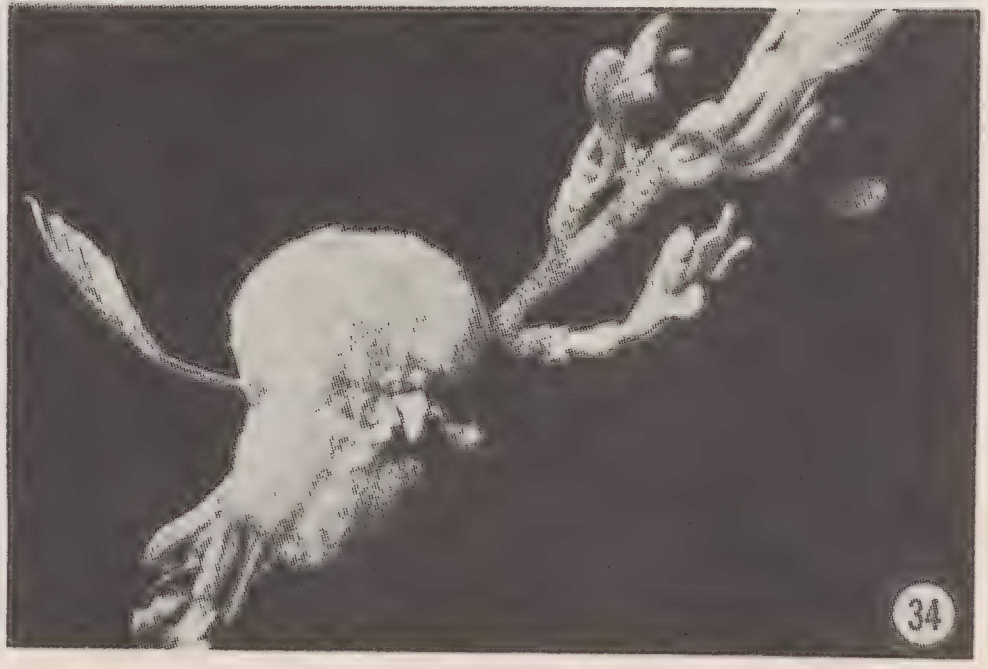
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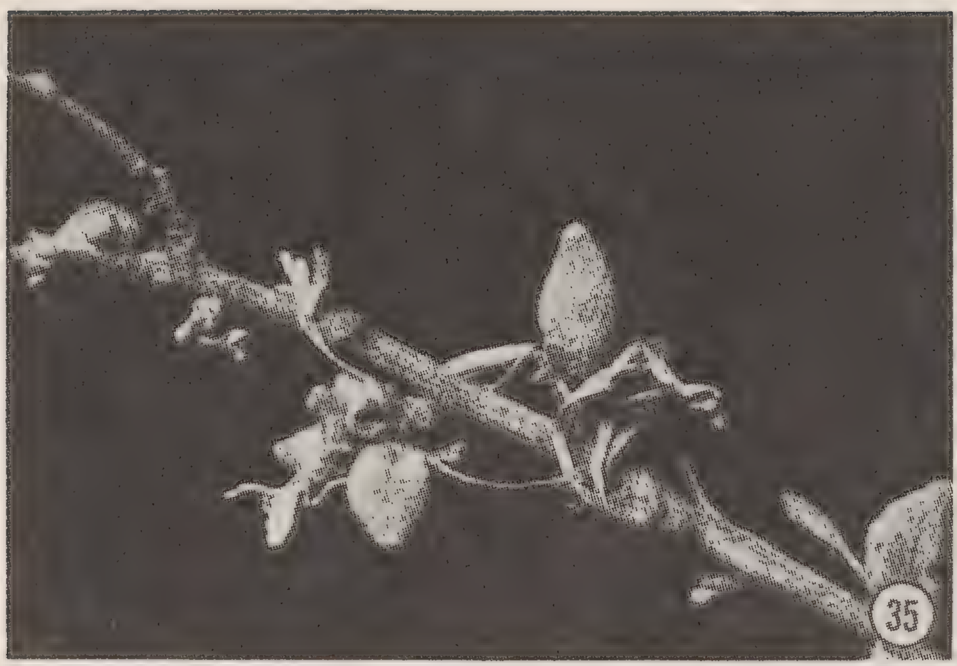
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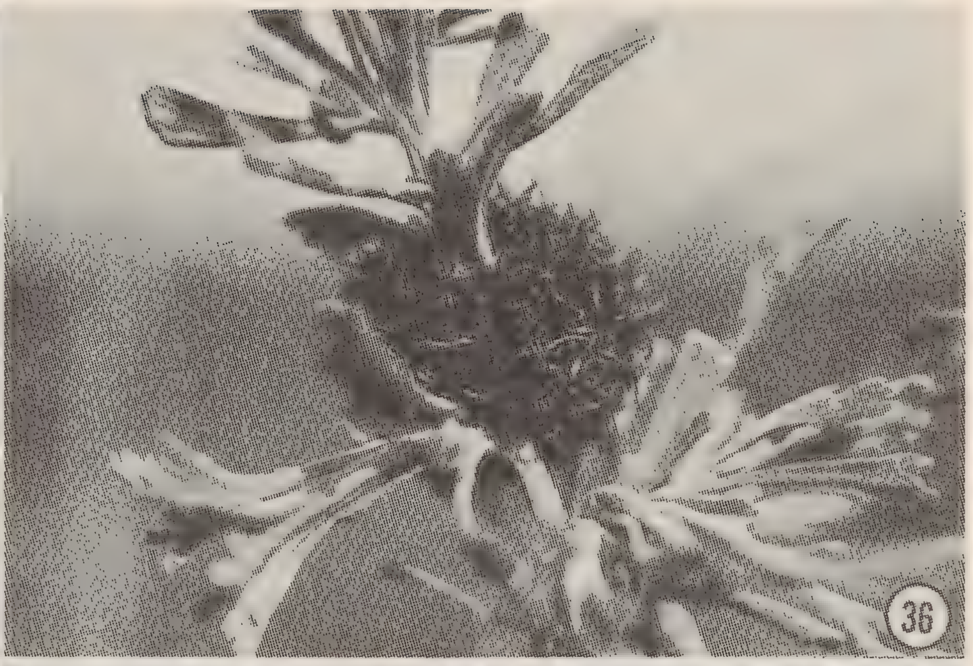
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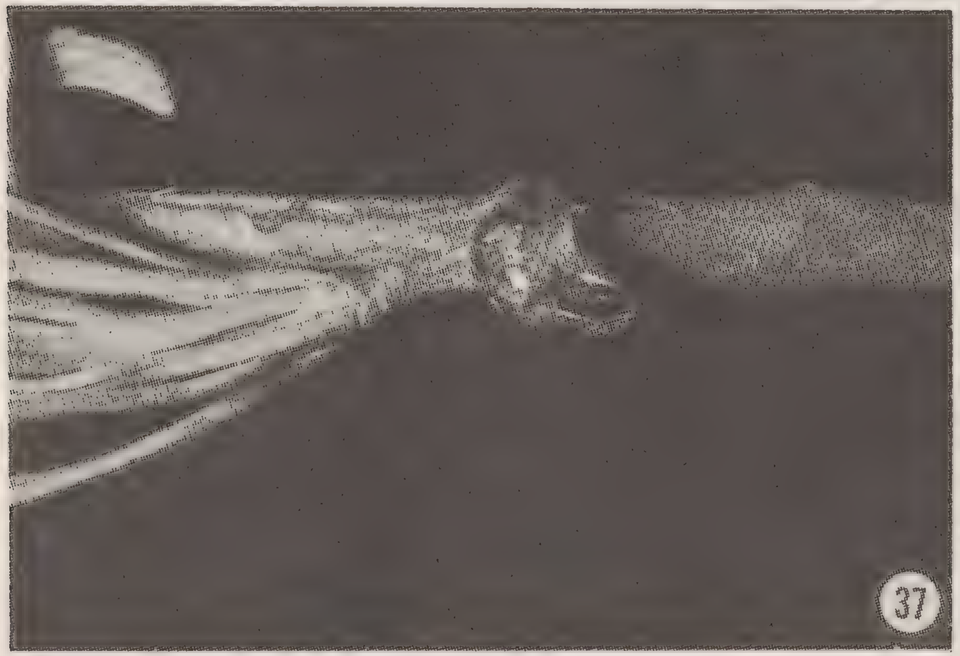
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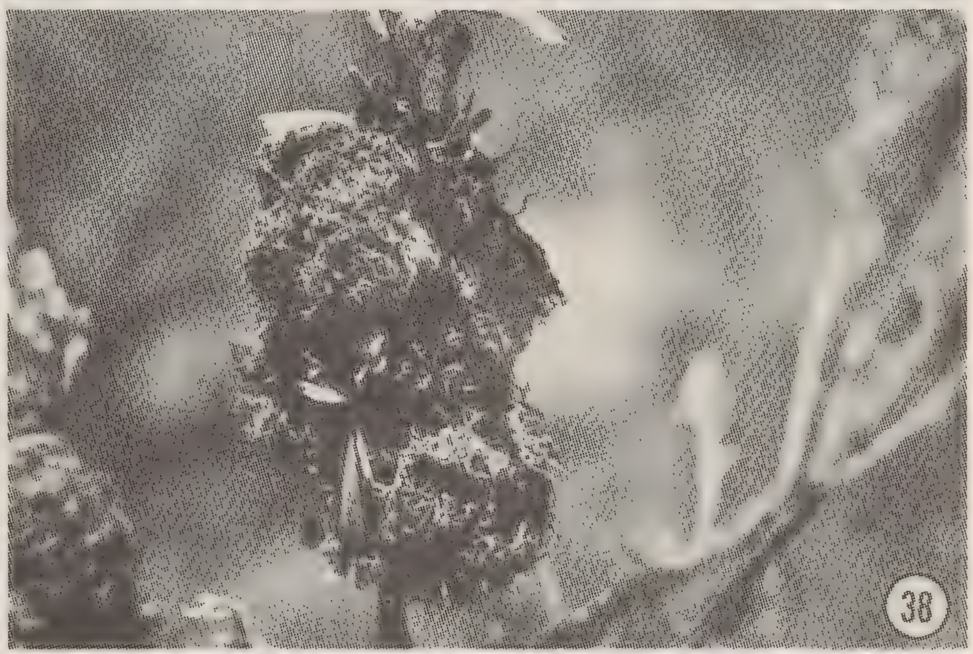
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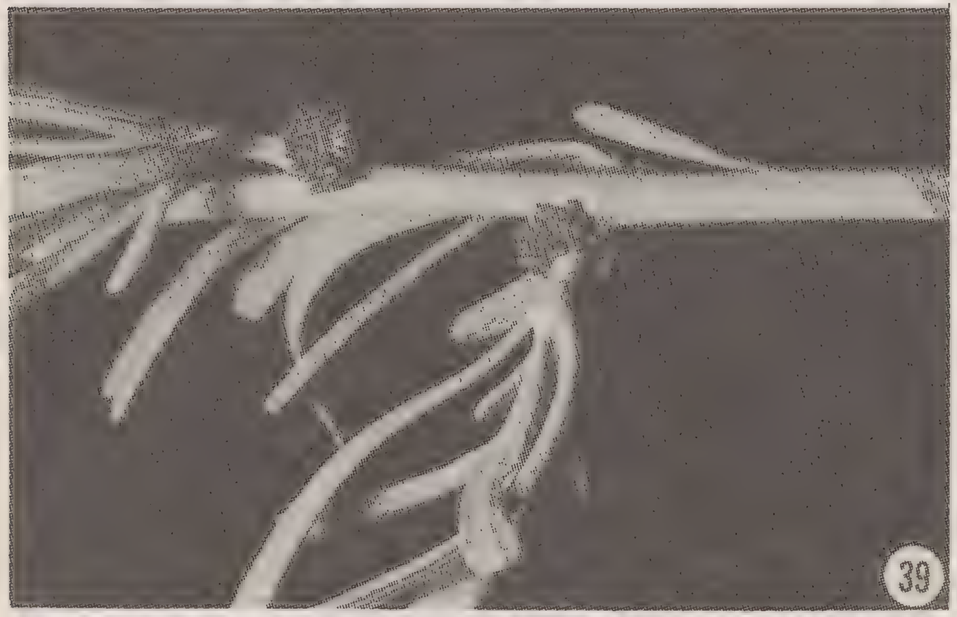
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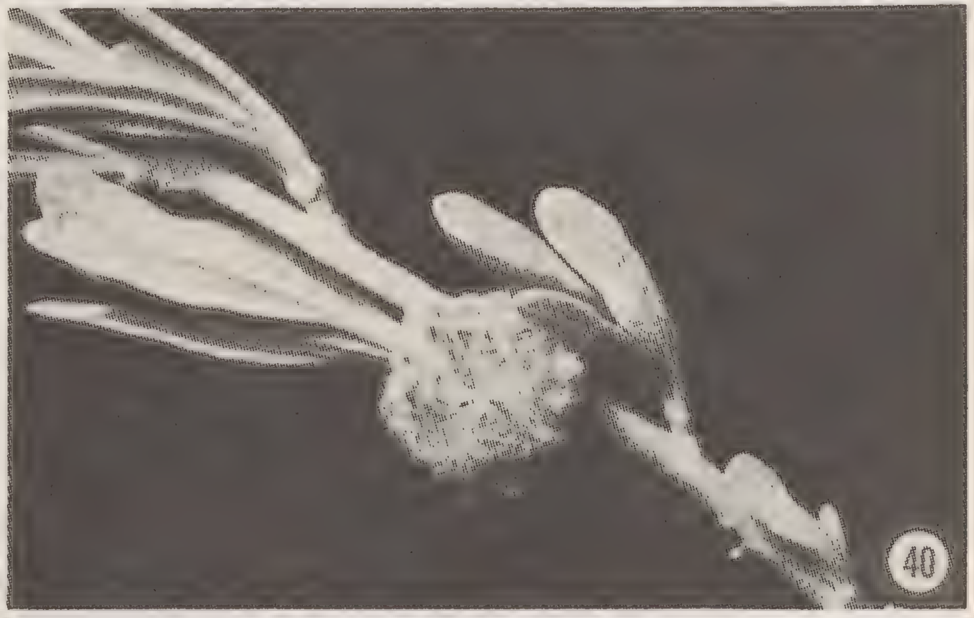
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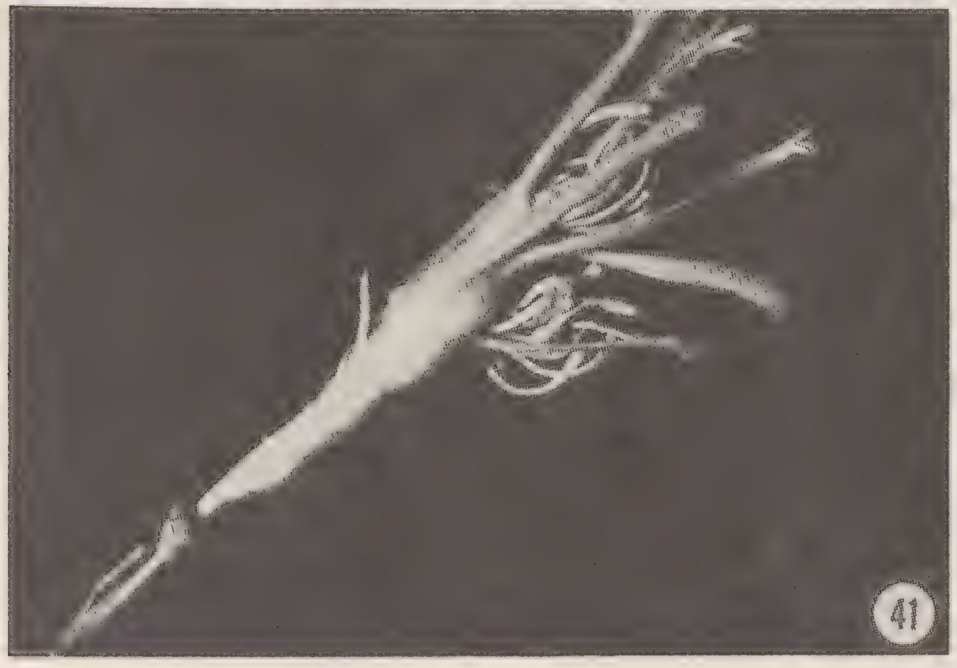
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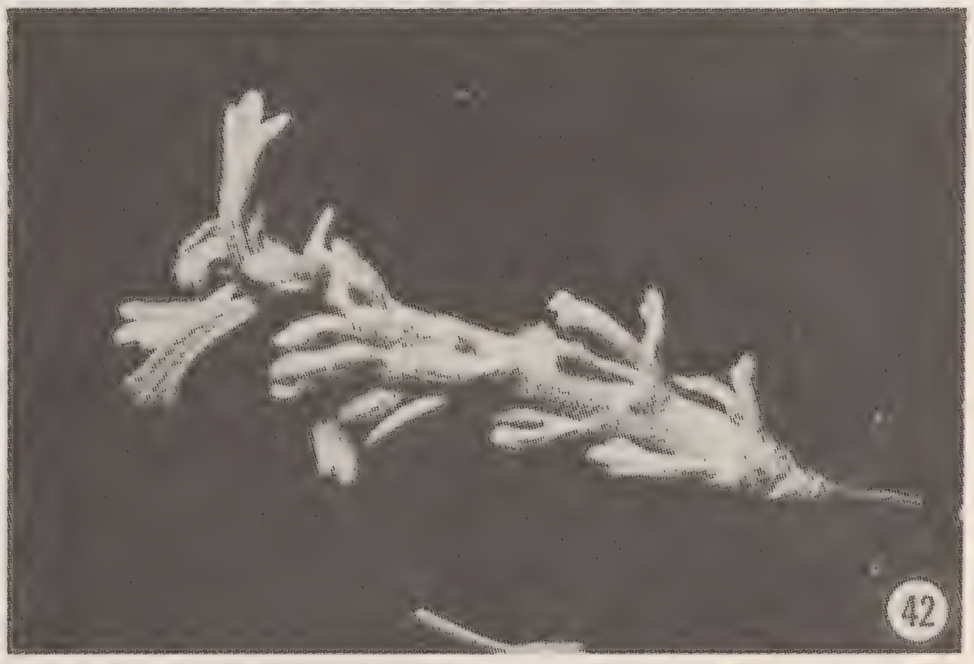
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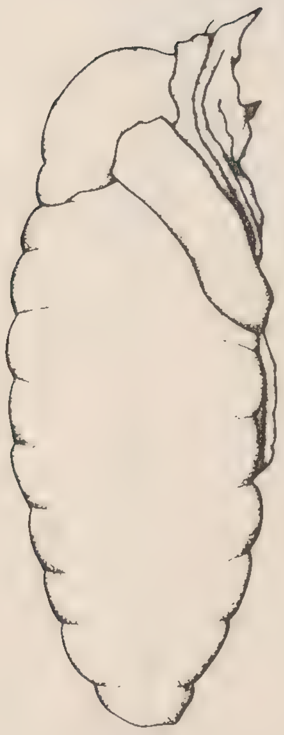

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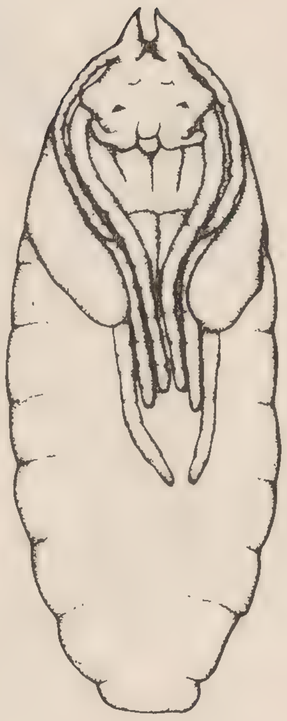

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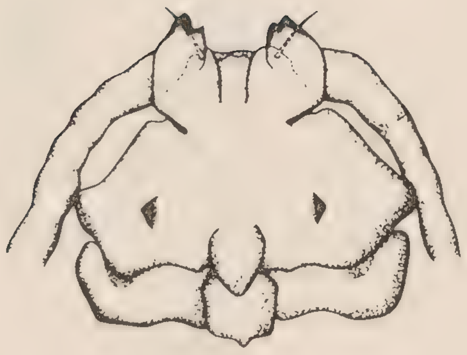

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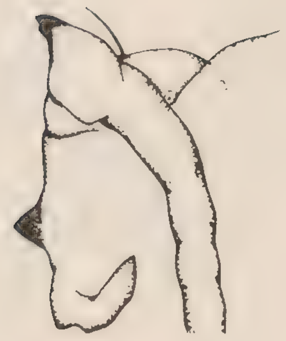

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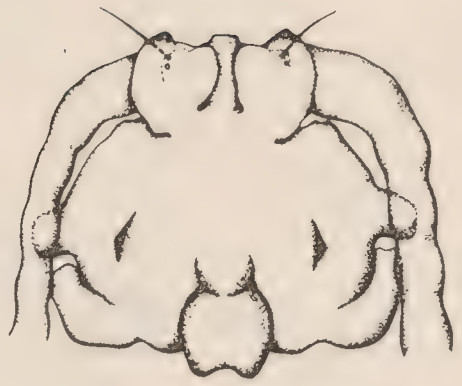

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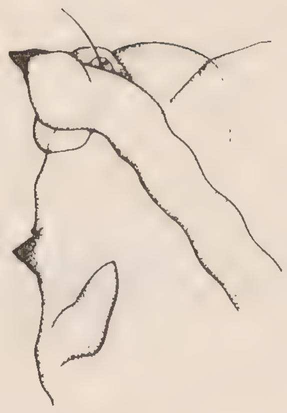

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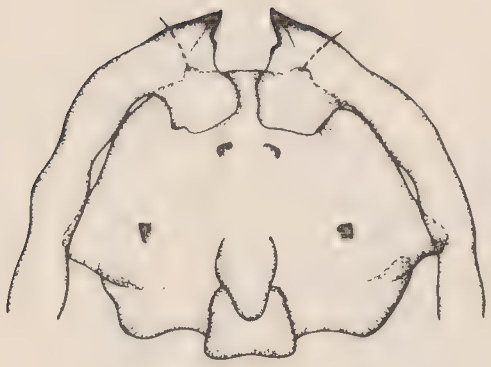

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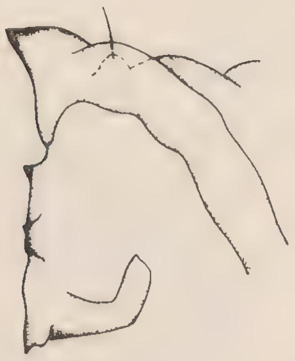

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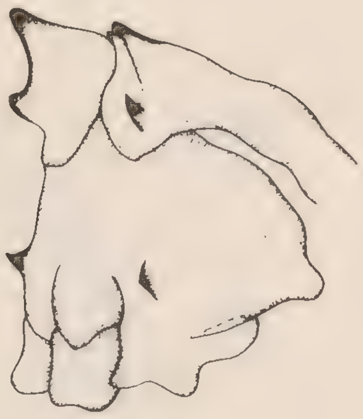

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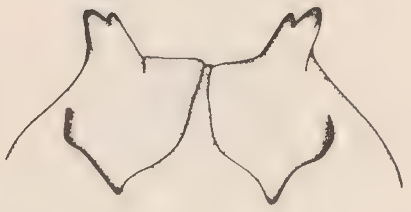

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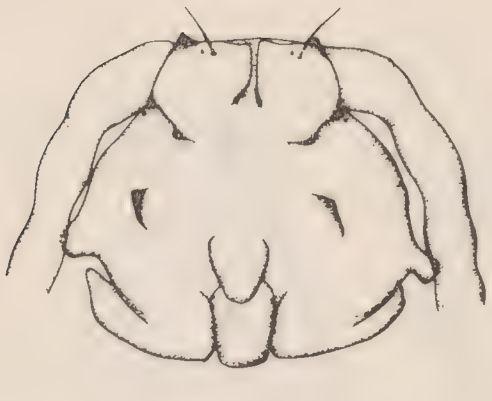

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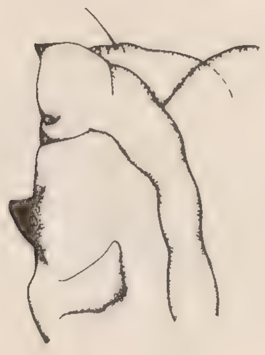

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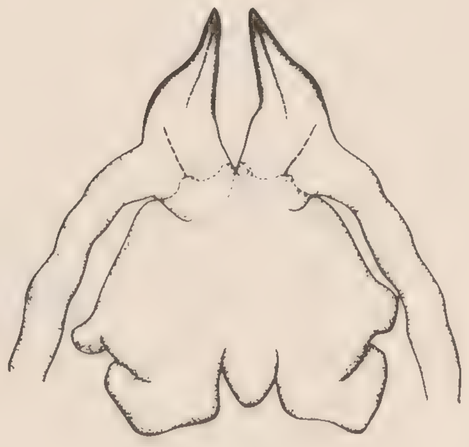

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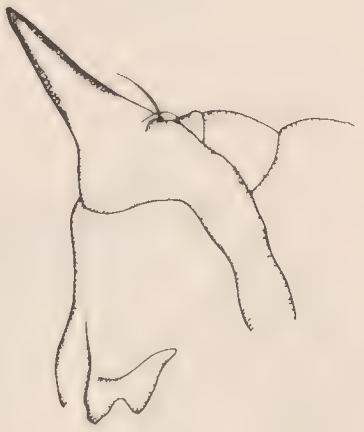

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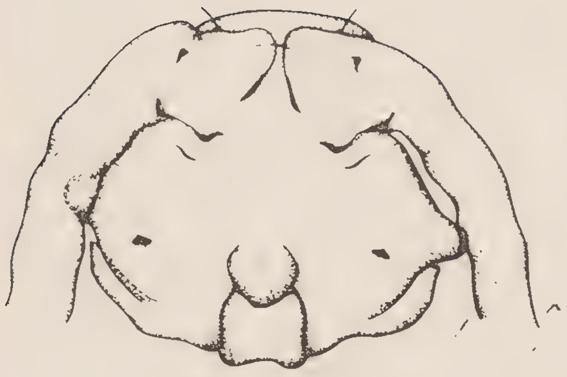
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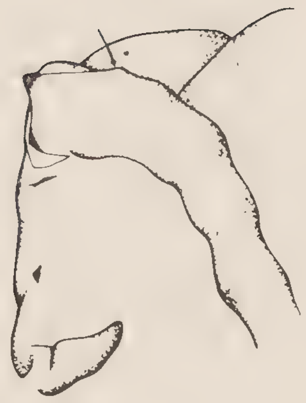
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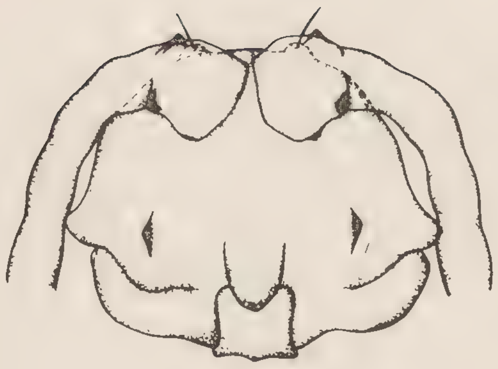
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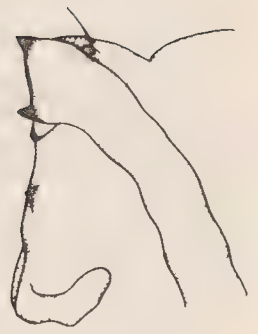
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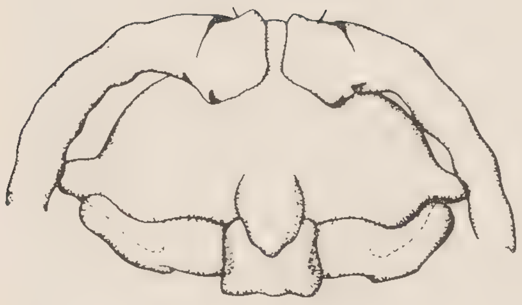
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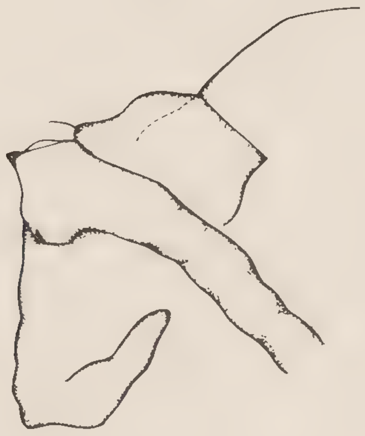
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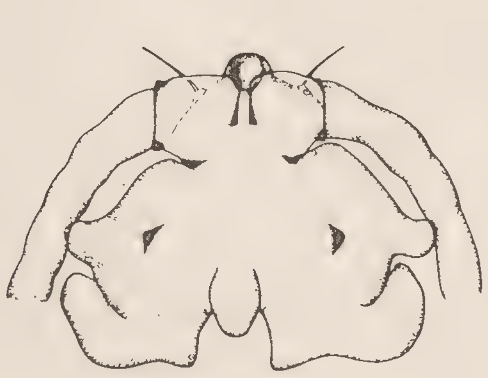
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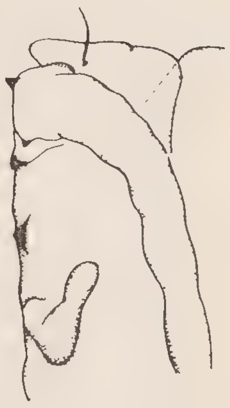
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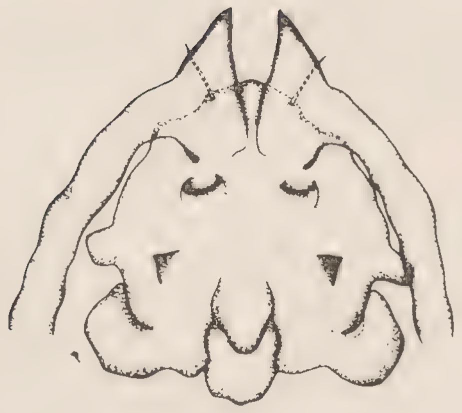
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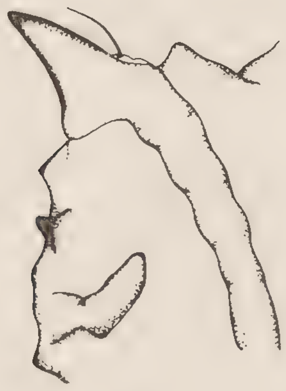
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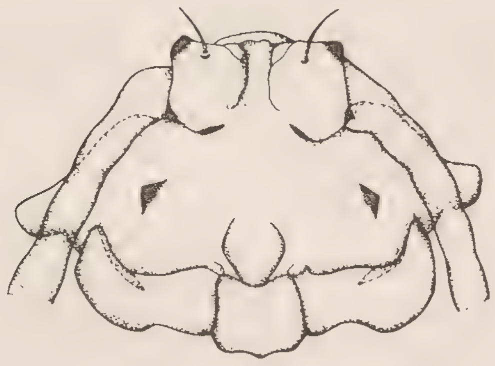
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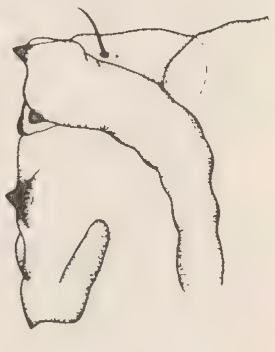
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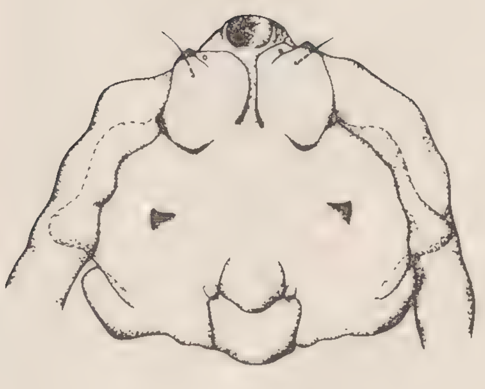
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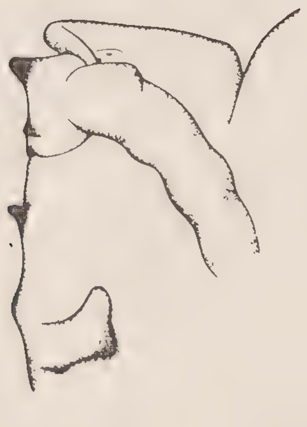
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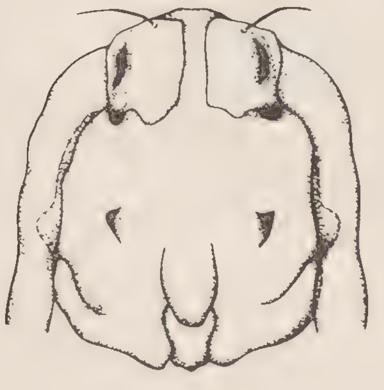
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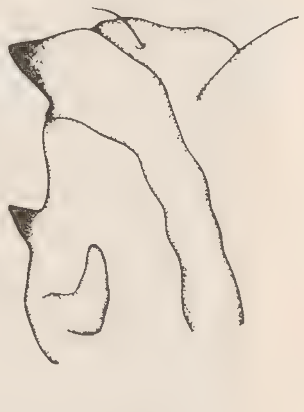
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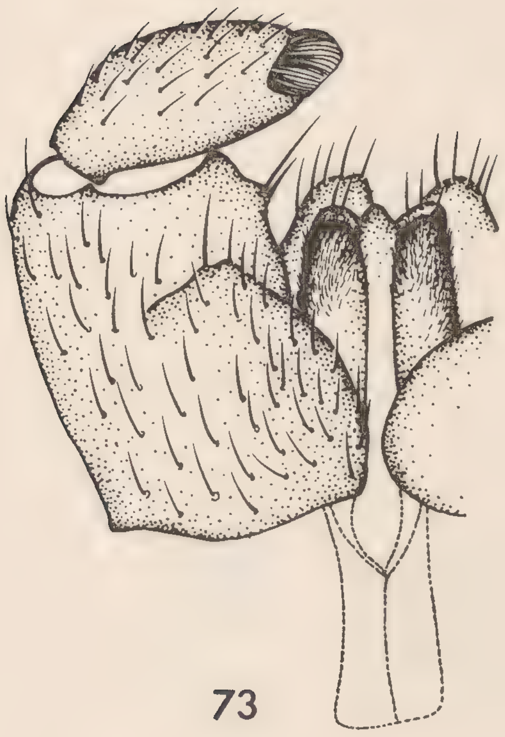

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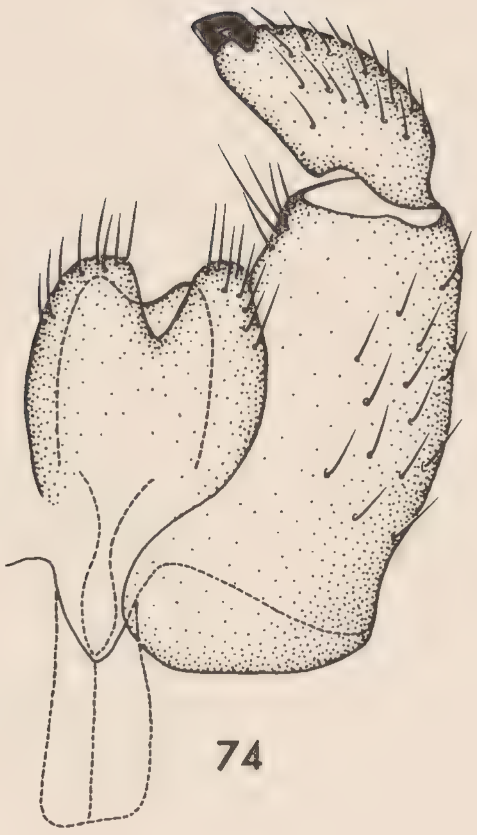

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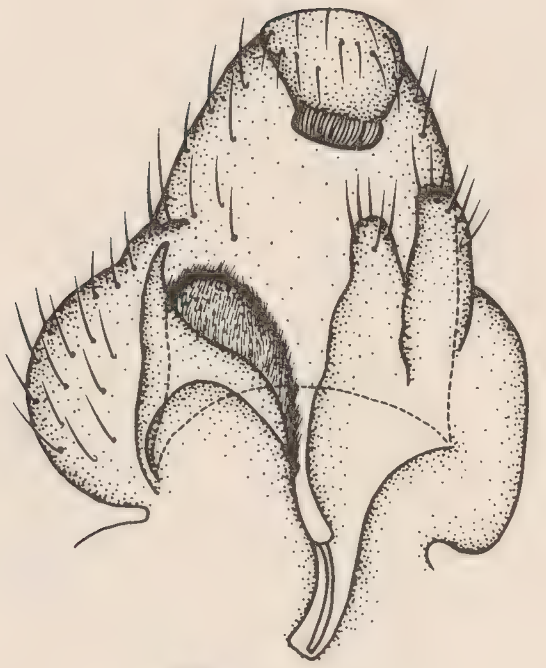

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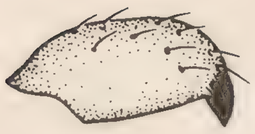

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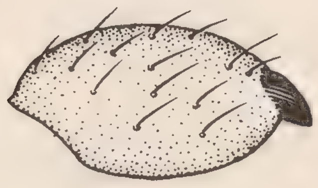

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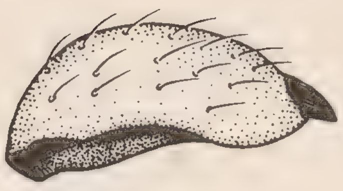

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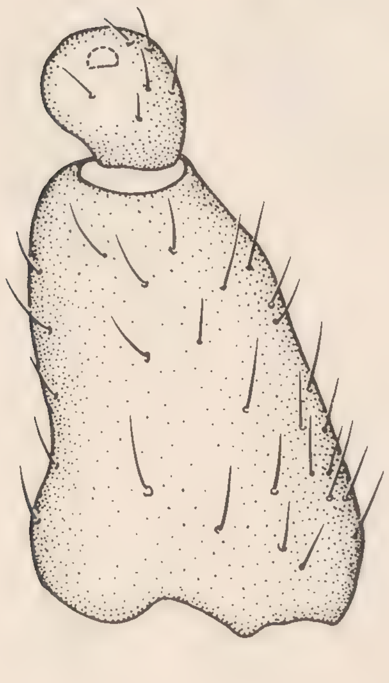

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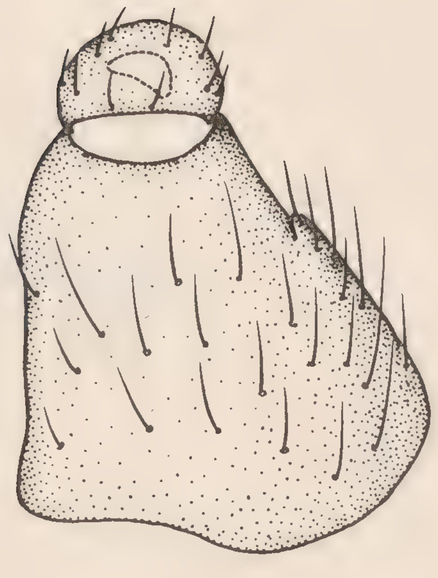

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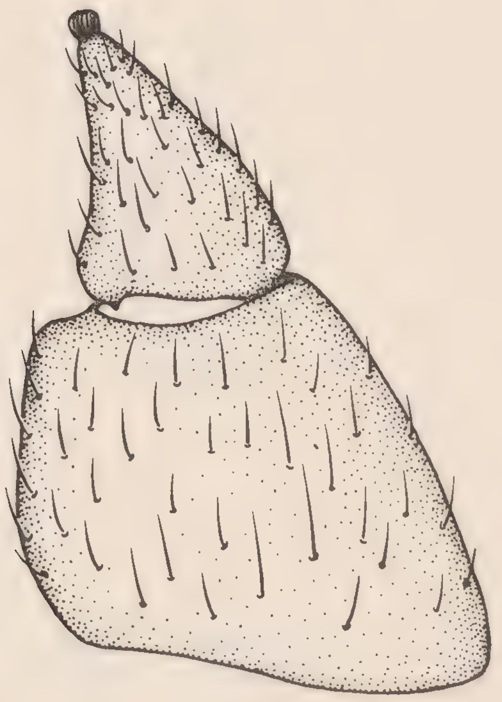

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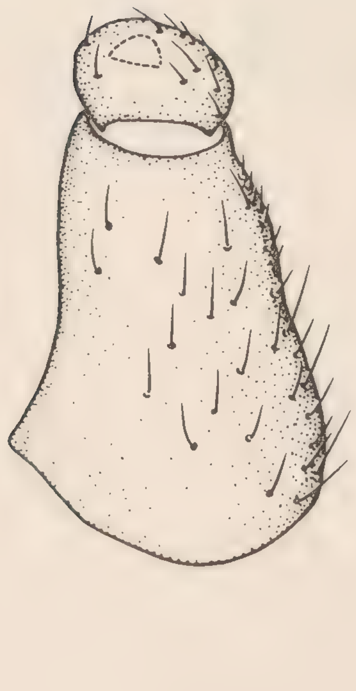

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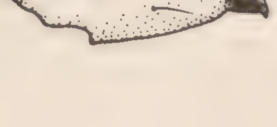

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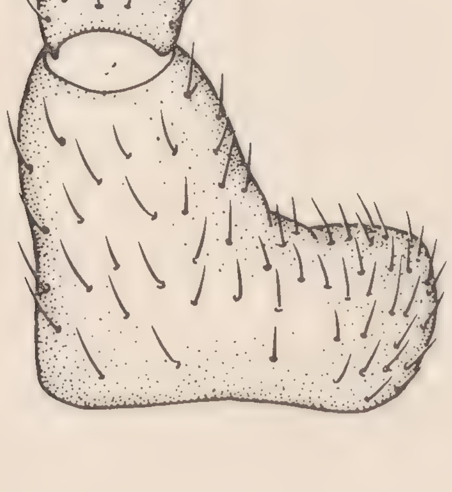

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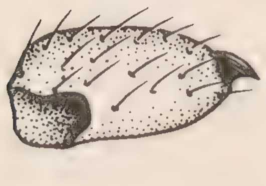

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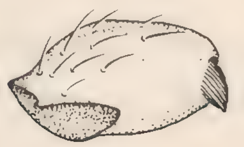

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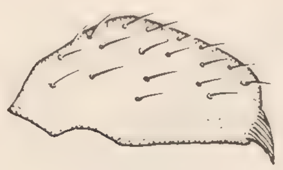

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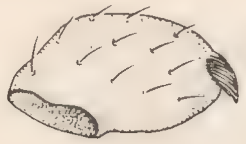

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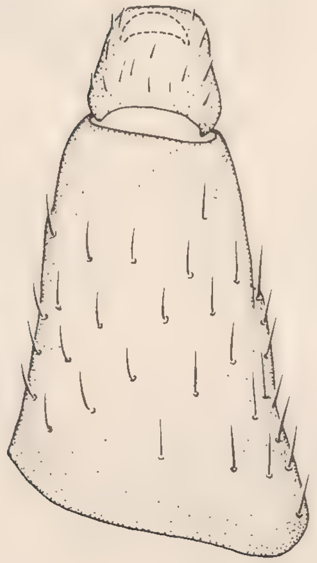

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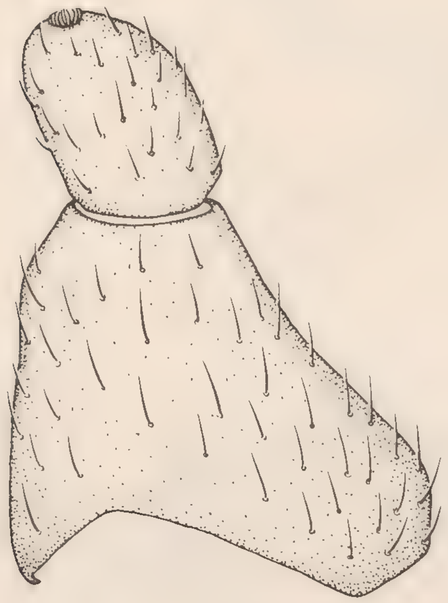

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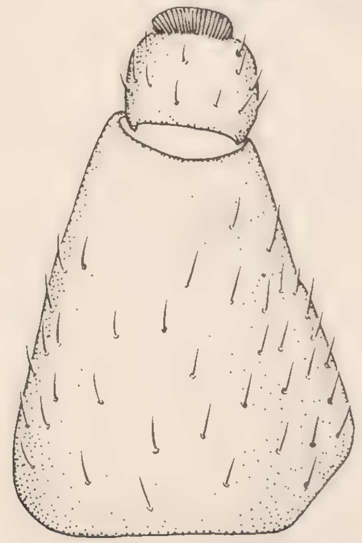

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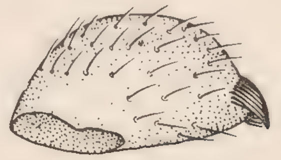

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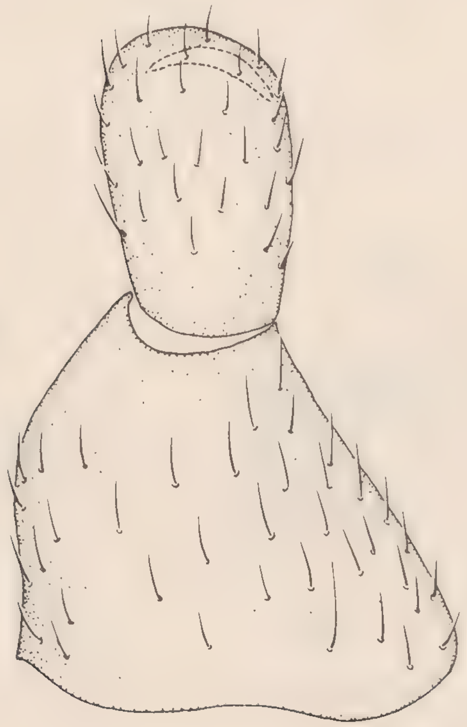

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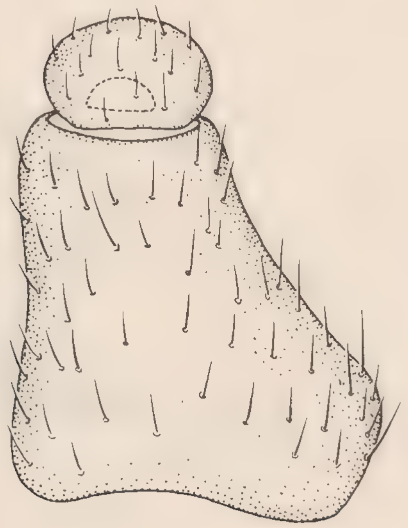

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